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## ABSTRACT

This study investigated the potential usefulness of a cognitive education intervention approach to improving learning abilities of underachieving Native adolescents. The specific variables considered were: (1) the manner in which this approach may affect cognitive development; (2) academic learning, (3) attitudes towards and interest in academic subjects; and (4) teacher attitudes towards such students. Subjects included 56 Native Cree Indian adolescents who were assigned to experimental (N=38) and control (N=18) groups based on their need for remedial or regular instruction respectively. Pretests were administered to identify underdeveloped cognitive functions and computer literacy was assessed via a computer awareness questionnaire. The experimental group received the intervention program, which comprised an introductory LOGO computer language component; an extended computer component; and reading, writing, and mathematics components. Posttests were then administered to both groups and an analysis of variance was conducted to determine the significance of any differences between the experimental and control groups. Results indicated that involvement in the intervention program did positively affect the experimental subjects' cognitive functioning abilities and improve their achievement in reading and writing; however, teaching for transfer of cognitive functions neither affected the students' attitudes toward academic subjects nor improved their achievement in mathematics. An extensive bibliography is provided, and copies of the computer awareness questionnaire, parent permission slips, and tables of contents for the program components are appended. (JB)

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COGNITIVE EDUCATION AND  
NATIVE ADOLESCENTS:  
A Pilot Study

Frederick I. Carnew, Ph.D.  
W. Bruce Clark, Ph.D.

INSTITUTE FOR  
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NATIVE ADOLESCENTS:  
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with the assistance of  
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To all of these people we express our gratitude and hope that in reading this report they will find the results as encouraging as we do.

November 18, 1985

FIC  
WBC

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## 1.0 INTRODUCTION

### 1.1. Introduction To The Problem

1.1.1 Over the past several decades, many attempts have been made to provide special programs to improve the learning achievements of Native adolescents. While such efforts have varied considerably, they essentially have been based on two models: remedial or supplementary education (for a general review, see Berger, 1977; Bowd, 1977; Hawthorn, 1967). Programs based on the remedial model have concentrated on upgrading of academic content and skills. In contrast, programs based on the supplementary model have emphasized the development of self-concept and cultural identity, with the expectation being that these factors would positively influence the Native adolescents' motivation to succeed in a regular academic program. Given the recurring high rate of drop-out and age-grade retardation found among Native adolescents (Berger, 1977; Canadian Education Association, 1984; Committee on Tolerance and Understanding, 1984; More & Oldridge, 1980; National Indian Brotherhood, 1972), both approaches appear to have been of limited effectiveness in assisting such students to achieve the abilities necessary for success in formal learning.

1.1.2 The evidence of the limited effectiveness of both approaches suggests that the phenomenon of Native adolescents poor academic performance must be considered as being more than isolated instances of skill, content, and identity underdevelopment. Vygotsky (1978) has argued that all phenomena should be studied as processes in motion and in change. For him, every phenomenon has a history, and this history is characterized by changes in form, in structure, and in basic characteristics. In the context of academically underachieving Native adolescents, Vygotsky's position would suggest that the process by which adolescents have arrived at their current condition has produced outcomes which must be considered when an appropriate academic intervention program is being designed. Included in this process is the students' history of formal schooling and, particularly, the adequacy of the program offered to them as it relates to the cognitive development of the students, the development of their ability to use strategies for efficient learning, and the students' own perceived relevance of the formal learning program.

1.1.3 A relatively large body of research has addressed the potential effect of an individual's history of formal schooling on that person's course of cognitive development. While much of this research has been concerned with cognitive performance in formally schooled as compared to non-schooled children (e.g., Cole & Scribner, 1974; Fjellman, 1971; Greenfield, 1966; Luria, 1971; Miller, 1973; Wagner, 1974, 1977), there are some

indications from the research findings that quality of schooling does influence cognitive outcomes (e.g., Goodnow, 1962; Holtzman, Dias-Guerrero, & Swartz, 1974; Pollnac & Jahn, 1976; Taylor & Skanes, 1975).

1.1.4 Many researchers and writers have commented on the inadequacies of Native education programs (e.g., Berger, 1977; Blue, 1982; Burnaby, 1982; Canadian Education Association, 1984; Hawthorn, 1967; MacArthur, 1968, 1969, 1973a, 1973b, 1975; Northwest Territories, 1982; Vernon, 1969). These identified inadequacies include, among others, irrelevance of the content to the perceived needs of the students, use of inappropriate reinforcement systems, inadequately prepared teaching staff, poorly defined educational objectives, paucity of intrinsically interesting learning materials, and an absence in teaching staff of genuine warmth and approval for the Native students. Where the quality of schooling experience is characterized by such inadequacies, the effectiveness in assisting the overall cognitive development of the Native child must be considered as potentially being less than adequate.

1.1.5 Several investigators have suggested that properly planned formal schooling should provide special kinds of learning experiences for its students (e.g., Greenfield & Bruner, 1969; Munroe & Munroe, 1974; Neisser, 1976; Scribner & Cole, 1973). Theoretically, such experiences should provide opportunities for the students' thoughts to be freed from the immediate social context. They should be enabled to consider problems hypothetically, to imagine alternative solutions and situations, and to evaluate these with no concern for everyday practicalities. In short, the school experience should assist Native students in their progress toward accomplishment of formal thought capabilities. Vygotsky (1978), in discussing the influence of formal school learning on the cognitive development of the child, contends that, while learning is not development, properly organized learning does result in cognitive development. Native adolescents who have not had access to such "properly organized learning" are at a disadvantage from a cognitive development viewpoint.

1.1.6 Lack of perceived relevance of the formal learning program has also been identified as a characteristic of many Native adolescent students (e.g., Berger, 1977; Blue, 1982; Burger, 1968; Hawthorn, 1967; Qirsualik, 1979). To be maximally effective, the formal schooling experience should be capable of assisting the student to transfer the strategies learned in the classroom situation to everyday life experiences (Northwest Territories, 1982; Redfield, 1963). Bruner (1960) has suggested that the important issue in education is not so much what we learn but what we can do with it. In other words, Bruner identifies the importance of being able to cross the barrier from learning to thinking. A survey of literature clearly

indicates that transfer of learning is an integral component in assessing the practical utility of any learning experience (e.g., Ausubel, 1963; Ausubel, Novak, & Hanesian, 1978; Belmont & Butterfield, 1977; Bower & Hilgard, 1981; Farnham-Diggory, 1976; Flavell, 1976). The underachieving Native adolescent may not have accomplished successfully this fundamental component of the formal learning process. In addition, this lack of perceived usefulness of the learning experience has presumably detrimentally affected the Native students' motivation to learn and attitudes towards academic subjects (Beiger, 1977; Bowd, 1977; Canadian Education Association, 1984; Hawthorn, 1967; Northwest Territories, 1982). Compounding these problems is the fact that past school attendance patterns of many underachieving Native adolescents is well established as being generally very poor (Canada, Indian and Northern Affairs, 1982; Canadian Association in Support of Native Peoples, 1976; Canadian Education Association, 1984; Committee on Tolerance and Understanding, 1984). As a result of these various problems, the cognitive development of underachieving Native adolescents may not have had the benefits of the complex training normally experienced by students in the formal learning program.

- 1.1.7 Adolescents who have had an unsuccessful experience in formal schooling are usually found to have inadequately developed learning skills (Brown, Bransford, Ferrara, & Campione, 1983; Rigney & Munroe, 1981; Siegler, 1983; Siegler & Richards, 1982). In brief, such students have not effectively learned how to learn in the classroom (Novak & Gowin, 1984). Where this has occurred, it has been found necessary to provide such students with a program which teaches the strategies and techniques for efficient learning as well as upgrading of specific content and skills

## 1.2. The Problem

- 1.2.1. The problem involved in this study addressed the relationship between Native adolescents' academic underachievement and the underdevelopment of cognitive functioning resulting from exposure to inadequate formal learning experiences. Essentially, the study examined one major question and three related minor questions. The primary focus was to identify and then through an intervention program to facilitate further development of particular cognitive functions requiring improvement for more effective participation in the academic education program. Secondly, the study examined the degree to which attention to improving cognitive functioning may positively affect student performances in certain academic subjects. Thirdly, the study examined the degree to which such an intervention program might affect the students' interest in academic learning as evidenced by the students' attitudes towards these academic subjects. Finally, the study examined how teachers' attitudes towards their Native students might be

affected by the experience of being involved in such a program. More specifically, the study asked the following questions:

1. To what extent can improved cognitive functioning be facilitated in academically underachieving Native adolescents?
2. Will the teaching for transfer of specific cognitive functions to certain academic subjects improve students' achievements in these subjects?
3. Will students' attitudes towards these academic subjects be affected by such a program?
4. Will involvement in such a program affect teachers' attitudes towards their Native adolescent students?

### 1.3. Purposes and Objectives

1.3.1 The overall purpose of this study was to examine the potential effectiveness of utilizing a cognitive education intervention program for Native adolescents who were not presently achieving success in the formal school system. The more specific objectives of the study were as follows:

1. To identify specific cognitive functions required for successful learning in mathematics and language arts (reading and writing) at the junior high school level;
2. To identify underdeveloped cognitive functions in a sample of Native adolescents characterized as academically underachieving by their teachers;
3. To identify current attitudes towards mathematics and language arts by this sample group;
4. To identify current performance levels in mathematics and language arts by this sample group;
5. To separate the sample group into two sub-groups, one of which was designated as an experimental group and the other designated as a control group;
6. To teach strategies for appropriate cognitive functioning to the experimental group;
7. To teach the experimental group to transfer appropriate cognitive functioning strategies to the study of mathematics and language arts (reading and writing);

8. To determine if such teaching for improved cognitive functioning results in improved cognitive performance by the experimental subjects relative to the control subjects;
9. To determine if such teaching for improved cognitive functioning results in improved cognitive performance by experimental subjects improved relative to the control subjects;
10. To determine if, after the intervention program, performance levels of experimental subjects in these academic areas improved relative to the control subjects; and
11. To determine if involvement in the intervention program affected teachers' attitudes towards the experimental subjects.

#### 1.4. Delimitations of the Study

- 1.4.1 The purpose of this study was delimited in two important ways. The list of cognitive functions to be considered was restricted to those presented by Feuerstein, Rand, Miller, and Hoffman (1980). It is acknowledged that this is not necessarily a representation of all cognitive functions required for successful learning at the junior high school level. The study was also restricted geographically and culturally to one group of academically underachieving Native adolescents. As a result, care will be necessary in considering generalization of results from this study to other geographic and cultural groups.

#### 1.5. Limitations of the Study

- 1.5.1 The study is limited by certain conditions beyond these researchers' control. The administration of the participating schools required that intact groups of students be involved in the study. As a result, the lack of random selection of subjects imposes some limitations on the generalizations to be made from results obtained.
- 1.5.2 Since this is the first study of this nature with this population, it must essentially be considered an exploratory study which may indicate the usefulness of further research.

## 2.0 SURVEY OF RELATED LITERATURE

### 2.1. Introduction

- 2.1.1. As a result of the work of writers such as Bruner, Olver, and Greenfield (1966), Cole and Maltzman (1969), Feigenbaum (1963), Flavell (1963, 1970), Sternberg (1969), and Vygotsky (1962, 1978), research attention has turned from an almost exclusive concern with context to that of the learner and, in particular, to the relationship between cognition and learning outcomes. While the research in the early 1970s concentrated primarily on developmental theories of cognition and of learning, increasing attention has been given by a number of developmental psychologists to the improvement of underachieving individuals' learning processes through cognitive education. Two groups of theorists, in particular, appear to have greatly influenced this interest: structural-modifiability theorists and information-processing theorists.

### 2.2. Structural-Modifiability Theory

- 2.2.1 Reuven Feuerstein, an Israeli psychologist, and his colleagues have developed a theory of human cognitive development which has as its base a concept of cognitive modifiability (Feuerstein, 1968; Feuerstein, Krasilowsky, & Rand, 1978; Feuerstein, Rand, & Hoffman, 1979; Feuerstein, Rand, Hoffman, & Miller, 1980). This theoretical approach describes the unique capability of humans to change, or to modify, the structure of their cognitive functioning in order to adapt to changing demands of life situations. This structural modification is seen as not only being a reflection of an organism's response to external stimuli, and changes in internal conditions, but as being also the product of a volitional act (Feuerstein & Jensen, 1980). Feuerstein states that such modification must be distinguished from biological or maturational change, and from fragmentary and transient changes (Feuerstein, 1968).
- 2.2.2 The theory states that structural modifiability is caused by two types of person-environment interactions: direct exposure learning and mediated learning experience (MLE) (Feuerstein et al., 1980, p. 15). Direct exposure learning is the result of direct exposure to stimuli from the earliest stage of development. This exposure is said to produce changes in individuals that affect their behavior and cognitive orientation. In turn, these changes affect learning throughout life to the extent that the stimuli present sufficient variation.
- 2.2.3 In contrast, mediated learning experience (MLE) is defined as the way in which stimuli presented by the environment are transferred by a "mediating" agent which is usually the parent.

This mediator places himself or herself between the individual and the environment, and "mediates, transforms, reorders, organizes, groups, and frames the stimuli in the direction of some specifically intended goal or purpose" (Feuerstein & Jensen, 1980, p. 409).

2.2.4 The structural-modifiability theorists believe that, through the process of mediation, the children are helped to focus on a higher level of awareness in certain segments of their immediate worlds (Feuerstein et al , 1978). In this way, it is believed that the interaction between children and their environments is enriched by mediators. This, in turn, changes the cognitive structure of the children.

2.2.5 Over the past several decades, Feuerstein and his colleagues have developed a distinctive cognitive-intervention program called "Instrumental Enrichment" (Feuerstein 1968, 1969, 1977; Feuerstein, Krasilowsky, & Rand, 1978; Feuerstein & Rand, 1977; Feuerstein, Rand, Hoffman, & Miller, 1980). This program, primarily intended for use with adolescents whose cognitive development has been diagnosed as deficient, formalizes and structures the mediated learning experience (MLE) component of his cognitive-modifiability theory. It is designed to develop new cognitive strategies and an awareness of general cognitive principles.

#### 2.2.6 Cognitive Functions

As described by Feuerstein, the Instrumental enrichment program considers cognitive functions in terms of four phases or components: input, elaboration, output, and affective-motivational (see Figure 2.1).

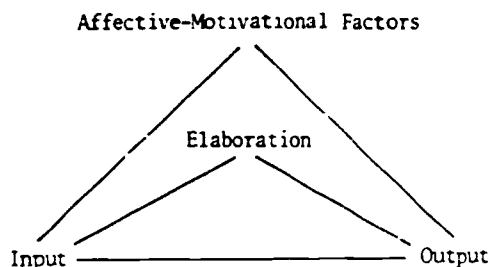
##### 2.2.6.1 Input Phase

Cognitive functions which influence the input phase include those which concern the quality and quantity of data collected by the adolescent as he prepares to attempt a problem-solving activity. Some of the functions noted by Feuerstein as being of particular importance at this phase of the mental act are:

1. Clear and accurate perception;
2. Planned, systematic exploratory behavior;

Figure 2.1

Relationships Among the Phases of the Mental Act



(Feuerstein et al., 1980, p. 75)

3. Receptive verbal tools and concepts which will assist discriminations;
4. Effective spatial orientation, including stable systems of reference to assist with the organization of space;
5. Efficient temporal orientation;
6. Conservation of constancies (e.g., size, shape, quantity, orientation) across variations in dimensions;
7. Precision and accuracy in data gathering; and
8. Consideration of multiple sources of information at once in order to deal with data as a unit of organized facts (adapted from Feuerstein et al., 1980, p. 73).

2.2.6.2 Elaboration Phase

Cognitive functions which affect the efficiency of the mental act at the elaborational phase include those functions which are required for the adolescent to make effective use of the data collected at the input phase. According to Feuerstein, the cognitive functions at this phase include:

1. Definition of the problem;
2. Selection of relevant, as opposed to irrelevant, cues;
3. Use of spontaneous, comparative behavior;
4. Breadth of the mental field; this determines the number of units of information which the adolescent can process simultaneously;
5. Summative behavior to identify the relationships between the stimuli;

6. Projection of virtual relationships;
7. Pursuit of logical evidence to support judgments;
8. Interiorization of behavior through use of representational mechanisms such as abstraction and generalization;
9. Inferential-hypothetical thinking; and
10. Use of planning behavior (adapted from Feuerstein et al., 1980, pp. 73-74).

#### 2.2.6.3 Output Phase

Cognitive functions which affect the efficiency of the mental act at the output phase include those functions required for adequate communication of the elaborative process. Feuerstein identifies the most important cognitive functions at this phase as being:

1. Effective communication modalities through which sufficient information is provided so that the receiver may fully comprehend the information provided;
2. Avoidance of blocking which could cause the adolescent to refrain from engaging in a problem-solving activity;
3. Clear verbal communication to ensure that the receiver may comprehend the information provided;
4. Use of accurate visual transport by which the adolescent conserves the image he has formed;
5. Use of precision and accuracy in communicating the response;
6. Avoidance of trail-and-error responses; and
7. Avoidance of impulsive, acting-out behavior when providing solutions to problem-solving tasks (adapted from Feuerstein et al, 1980, p. 74).

#### 2.2.6.4 Affective-Motivational Components

The willingness of the adolescent to engage in a mental act requires a volitional, intentional, and purposeful effort (Feuerstein et al., 1980, p. 102). Without the intrinsic motivation necessary for such an effort to be made, it is unlikely that the adolescent will attempt to efficiently utilize the cognitive functions required.

## 2.2.7 Instrumental Enrichment Program

Feuerstein and his colleagues developed the Instrumental Enrichment program to assist adolescents to improve their abilities to more efficiently utilize each of the cognitive functions. Essentially, it is designed to provide for lack of mediated learning experience (MLE) believed to be the cause of underdeveloped cognitive functioning. Its primary goal is to enable the individual to function cognitively at a "normal" level. More specific objectives established for its use are: (a) the correction of specific deficient functions; (b) acquisition of basic concepts, labels, operations, and relationships needed for mastery of specified cognitive tasks; (c) production of intrinsic motivation through formation of appropriate habits; (d) production of reflectful, insightful, and introspective processes in the individual; and (e) development of a positive self-perception whereby an individual views himself as not only a passive user, but also an active generator of information (Feuerstein et al., 1980, pp. 115-123).

### 2.2.7.1 Bridging

The 500-plus pages of paper-and-pencil exercises are divided into fifteen units or "instruments," each of which emphasizes a particular cognitive function. These instruments are designed to be as content-free as possible, since the primary focus is on correction of underdeveloped cognitive functions rather than on acquisition of subject matter. Training for transfer involves what Feuerstein and his colleagues call "bridging" (Feuerstein et al., 1980). Subjects learn a general principle, and are then helped to see how this principle applies to particular situations such as real life social problem-solving, learning of academic subjects, etc. Implicit instruction is given in the range of applicability of the concept. The assumption underlying bridging is that children need to see how particular principles apply to new situations since, without deliberate attention to such transfer, it is thought that these principles may not be utilized in novel situations (Feuerstein et al., 1980, pp. 289-301).

### 2.2.7.2.0 Teacher Training

A further characteristic of the Instrumental Enrichment program is that extensive teacher-training is a necessary requirement for its use. Feuerstein contends that the teacher is a crucial variable in the potential success of the intervention (Feuerstein et al., 1980, pp. 293-306). Four goals are outlined for the teacher-training component of the program. These are:

1. Training for understanding and acceptance of the underlying theory of structural-modification;

2. Mastery of the tasks themselves;
3. Training in the didactics of the program; and
4. Training for insight, bridging, and application of the required process.

2.2.7.2.2 A variety of approaches is used in the training process. These include extended in-service workshops of at least one week's duration, workshops during vacations, and local workshops during the year. Training techniques include lectures, discussions, videotapes of lessons, written protocols of lessons, modeling, and simulation. Ideally, a teacher using the program is assigned a consultant, i.e., a master teacher, for the first two years of implementation. This expert provides support to the teacher through bi-weekly classroom visits and consultation.

2.2.7.2.3 Feuerstein and his colleagues have found that, without the extensive training component, teachers are less effective in attempting redirection of cognitive development with their students. Typically, it has been found that teachers tend to have low expectations of the abilities of their academically underachieving students (Feuerstein et al., 1980, p. 293). This attitude may result in the teacher practicing a passive-acceptant approach and failing to use effective teaching techniques to encourage the students' thought processing. Similarly, the developers have found that, without training, the teachers may place too much emphasis on output instead of also concentrating on the input and elaborational phases of the mental act and on the students' ability to apply the principles and strategies being learned.

Feuerstein emphasizes the interdependence between the teacher's awareness, skills, and attitudes and the progress of the student towards further cognitive development. The teacher provides the assistance through which the student acquires the concepts, the vocabulary, and the operations. The production of insight, or metacognition, is dependent on the teacher's capacity to focus the student's attention on those cognitive functions required for efficient mastery of the particular task being undertaken. The teacher's knowledge assists the student to bridge from the specific tasks in the Instrumental Enrichment program to the broader areas of behavior in academic learning and in everyday life activities. The student's motivation to continue involvement in the intervention program is determined by the ability of the teacher to provide positive reinforcement and feedback to the student. The teacher has to be capable of acting as a model for the students, demonstrating the efficient use of appropriate functions in particular tasks.

- 2.2.7.2.4 In return for their investment in training and in teaching the Instrumental Enrichment program, Feuerstein claims that teachers themselves undergo modification of their own cognitive functioning and of their awareness of students' needs and abilities (Feuerstein et al., 1980, pp. 293-306). Teachers raise their level of expectation of student performance, are more inclined to encourage abstract thinking from their adolescent students, are likely to be more flexible in their teaching, and develop a more sensitive understanding of the difficulties being experienced by their students. In short, Feuerstein claims that the Instrumental Enrichment program is effective in modifying teachers as well as students.

## 2.2.8 Research Involving The Instrumental Enrichment Program

- 2.2.8.1 The Instrumental Enrichment program has been implemented in a variety of settings and countries (cf. Haywood & Arbitman-Smith, 1981). In general, significant gains have been found at the conclusion of these interventions (cf. Feuerstein, Miller, Hoffman, Rand, Mintzker, & Jensen, 1981; Feuerstein, Rand, & Hoffman, 1979; Feuerstein, Rand, Hoffman, & Miller, 1980). As an example, in an experiment involving 551 students (including urban, upper-middle-class students; urban, lower-class students; and educable mentally retarded students), Feuerstein et al. (1979) found significant improvement in analogy scores as a result of both verbal and figural training. Some immediate transfer was also found in that verbal training improved figural performance substantially. Feuerstein et al. (1980) state that the more remarkable gains appear to occur three to five years after program termination. Feuerstein suggests this reflects the impact this training had on the cognitive structures of the individuals involved. Research, however, has still to show a direct causal relationship.
- 2.2.8.2 Instrumental Enrichment is also currently being used with Navajo Native adolescents at Shiprock Alternative High School in New Mexico. While research results are still not available, anecdotal reports suggest that the program is being effective in changing the cognitive structures of these students (Emerson, 1984, 1985; Feuerstein, 1985; Jensen, 1985). Emerson (1985) reports that the program has had positive influence on the whole school. School attendance has increased by 44% over a three-year period. The teachers report that the program has helped them to become more "precise and accurate" and more cognizant of their own need to be proficient and organized in their daily lives and in work. Emerson also reports that some parents have indicated the program has effected positive changes in the students' behavior at home.

2.3 Information-Processing Theory

- 2.3.1 In contrast to Feuerstein and his colleagues, information-processing theorists see learning processes as constituting the acquisition and use of behavior (Snelbecker, 1974). Learning and behavior reflect conjoint effects of the information processed and the kinds of retrievable and usable information stored internally in the organism (Bower & Hilgard, 1981). The theory assumes that humans have an internal representation (set of images) for both current and previous external and internal environments. The basic components of the information-processing system are identified as being: (a) sensory receptors that receive inputs from the environment; (b) effector units that produce responses; (c) a memory store that holds action programs; and (d) a central processor where the major mental activities occur (for details, see Bower & Hilgard, 1981).
- 2.3.2 Neisser speaks of cognition as being the "activity of knowing: the acquisition, organization, and use of knowledge" (Neisser, 1976, p. 1). Sternberg (1981a) amplifies this construct of cognition by describing the processes involved in this "activity of knowing" (i.e., cognitive processes) as being those processes of which an individual makes use when mentally representing and processing information. He lists perception, learning, memory, reasoning, problem-solving, and decision-making as some of the processes involved in cognition.
- 2.3.3 In respect to modifying the functioning of these processes, Sternberg (1981a) argues that intervention will not be effective if it only attempts to deal with one particular aspect of the functioning cognitive system. Because he believes these various processes are highly interactive (Sternberg, 1979), he contends that permanent cognitive developmental change will only be realized if these interactions are taken into account. He further suggests that even this consideration will be insufficient unless the intervention program is also directed toward modification of the individual's motivational sets (Sternberg, 1981a). Without the inclusion of this factor in a cognitive intervention program, Sternberg argues that the same motivational factors that led to depressed or underdeveloped cognitive performance in the first place will eventually reassert themselves and lead again to "depressed performance of the modified cognitive repertoire" (Sternberg, 1981a, p. 179).
- 2.3.4 Information processing theorists express concerns over the underdevelopment of appropriate strategies for learning. Strategies, according to Siegler and Richards, may be thought of as being a "qualitative algorithm with the variables corresponding to cognitive processes. Such an algorithm may include both the conditions under which it is to be used and the processes

involved in its execution" (Siegler & Richards, 1982, p. 923). Such strategies are used by a learner to improve acquisition, retention, and retrieval of representational and procedural knowledge (Rigney & Munro, 1982). These processing operations are initiated by orienting tasks that may be self-assigned or imposed by a teacher or by an instructional system. Rigney and Munro (1981) also point out it is likely that individual students develop their "idiosyncratic ways of learning" over long periods of time, and that they continue to use these strategies, even those that are inefficient, because they are familiar and have familiar outcomes.

- 2.3.5 The educational research literature contains many studies of learning strategies, with subjects from populations ranging from early primary school or university, and subject-matter ranging from simple verbal learning to mathematics and problem-solving (cf. O'Neil, 1978; O'Neil & Spielberger, 1979). In general, these studies suggest that learning strategies may operate at the unconscious level only after long practice in using them has resulted in automatization.
- 2.3.6 Memorial capacity limitations are believed to stem from several sources including limited storage capacity (Miller, 1956), limited resources of attention (Kahneman, 1973), and limited processing speed (cf. Zeichmaster & Nyberg, 1982). It is suggested that underdevelopment of effective strategies in any or all of these sources may profoundly contribute to cognitive underdevelopment (Capione et al., 1982; Siegler, 1983; Siegler & Richards, 1982).
- 2.3.7 According to many information-processing theorists, the mastery of increasingly sophisticated mnemonic strategies involving rehearsal seems to play an important role in cognitive development (for review, see Baron, 1978). Investigators have shown that strategies are used in all phases of the memorial process: when the information is initially encoded, when it is stored, and when it is finally retrieved. Additionally, developmental differences have been found in both the probability of use (Keeney, Canizzo, & Flavell, 1967) and quality of such strategies (Ornstein, Naus, & Liberty, 1975). As a result, Brown and her colleagues suggest that a source of cognitive underdevelopment may be lack of development, or ineffective use, of such strategies (Brown et al., 1983).
- 2.3.8 In addition to rehearsal strategies, it has been suggested that cognitive underdevelopment is characterized by poor organization of to-be-learned material (Borkowski & Konarski, 1981). This suggestion has been advanced as a result of developmental differences found in the way word connections are organized (Goldberg, Perlmutter, & Myers, 1974; Hasher & Clifton, 1974), in the quality of semantic organization (Flavell, 1970), and in the use of categories and categorization schemes (Moely, 1977).

- 2.3.9 Developmental differences have also been found in children's use of elaboration strategies. Spontaneous use of such strategy increases with age (Paris & Lindauer, 1976). Similarly, older children are found to benefit more from self-developed elaborations while younger subjects seem to find elaboration developed by others to be more beneficial (Reese, 1977). It is believed that a cause of inadequate performance may be an inability to efficiently elaborate material in order to assist memorization (Campione & Brown, 1977).
- 2.3.10 Information-processing theorists interested in underdeveloped problem-solving abilities have tended to seek explanations in the interface between the problem-solver and the task environment. They have examined the demands imposed by different tasks in order to discover the regular patterns of strategies that children of different ages bring to the problem-solving activity. The different task-analytic techniques they have used--computer simulations, flow-chart analyses, and analyses of underlying principles--have emphasized psychological processes of different levels of specificity. These have included, among many others, transitive inference (e.g., Bryant & Trebasso, 1971; Sternberg, 1980), analogical reasoning (e.g., Sternberg & Rifkin, 1979), conservation (e.g., Klahr & Wallace, 1973, 1976; Siegler, 1981), and counting (e.g., Gelman & Gallisteel, 1978). The findings from research such as this indicate that individuals who demonstrate cognitive underdevelopment have not learned to use appropriate strategies for efficient cognitive functioning (for further discussion, see O'Neil, 1978; Siegler, 1983).
- 2.3.11 Brown (1978) and Flavell and Wellman (1977) have suggested that understanding of one's own cognitive processes, i.e., metacognition, is necessary for effective cognitive performance. Vygotsky (1962) describes two phases in the development of knowledge: first, its automatic unconscious acquisition, followed by gradual increases in active conscious control over that knowledge. Brown (Brown, Bransford, Ferrara, & Campione, 1983) suggests that this distinction is essentially the separation between cognitive and metacognitive aspects of cognition.

Flavell defines metacognition as:

"one's knowledge concerning one's own cognitive processes and products.... Metacognition refers, among other things, to the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete goal or objective."  
(Flavell, 1976, p.232)

- 2.3.12 The skills of metacognition are those attributed to the executive: predicting, checking and monitoring, reality testing and coordination, and control of deliberate attempts to study, to learn, and to solve problems (Brown, 1978). According to information-processing theorists, these are the basic characteristics of thinking efficiently in a wide range of learning situations. They point out that self-interrogation concerning the current state of one's own knowledge during learning, or during any problem-solving task, is an essential skill in a wide variety of situations including those of school or of everyday life situations.
- 2.3.13 Within this construct, a major reason of cognitive underachievement is seen as being immature metacognitive knowledge and skills (Brown et al., 1982; Brown et al., 1983; Ryan, 1982). Students who understand how their minds work, how to approach solving of particular problems, and why some problem-solving attempts tend to be more successful than others, are using metacognitive skills. Although research on metacognitive differences in learners is in its early stages, existing evidence (for review, see Brown et al., 1983) confirms the prediction that less successful learners are inefficient at judging how difficult a task is, at identifying possible strategies for solving the task, and at evaluating the relative merits of those strategies. Moreover, they are also much less aware than are successful learners of the purpose of learning (Rumelhart, 1977).
- 2.3.14 A further cause of cognitive underdevelopment, identified by Sternberg (1981a), is lack of motivation which he regards as the force that acts to energize, direct, sustain, and terminate cognitive behavior. In this context, the level at which individuals are motivated is critically linked to the level of their strategic activities since employing strategies requires more sustained effort than behaving passively. Moreover, regulation of effective use of strategies at the executive level requires even additional effort and attention (Ryan, 1982). As a result, an individual's decision to perform at an optimal level depends on that person's analysis of the benefits to be accrued for the cost expended (Cannino, 1981).
- 2.3.15 Research on what individuals believe to be the causes of their own successes and failures has indicated important differences in cognitive development that appear to be directly related to the passive performance of less successful learners (for discussions, see Diener & Dweck, 1978; Dweck, Davidson, Nelson, & Enna, 1978; Dweck & Reppucci, 1973; Maier & Seligman, 1976; Miller & Norma, 1979; Seligman, 1975). Successful learners attribute their successes to internal circumstances and their failures to lack of ability. Unsuccessful learners tend to exhibit the symptoms of "learned helplessness" (Seligman, 1975)

in that they expect to fail, and feel there is nothing they can do about it. Due to their history of failure, the causes to which they attribute their failures, and the greater effort required of them, less successful learners are unlikely to behave strategically except in conditions where they are specifically guided by a teacher and specifically reinforced for both the desired activities and the products of their efforts.

- 2.3.16 Recently, some information-processing researchers have suggested that knowledge of specific relevant content is a crucial dimension of development (for review, see Brown et al., 1983). Differences in prior knowledge have been suggested as a major factor in cognitive differences between children and adults (Siegler & Richards, 1982). As a result, it is felt by some researchers that one of the major causes of poor performance is lack of basic knowledge required for effective processing of information (Chi, 1981; Siegler, 1981, 1983).
- 2.3.17 Unlike Feuerstein, information-processing theorists have not developed a specific intervention program for cognitive modifiability. Instead, much of the research involved has concentrated on development of particular strategies, primarily within three key areas. The area receiving most attention by researchers has been the presentation of intervention programs for teaching strategies directed towards the improvement of cognitive functioning in children. Concentrating primarily, but not exclusively, on young mentally-retarded subjects, findings from this research suggest that teaching of strategies is an effective method of improving cognitive performance. A second area of training that has received considerable attention by information processing psychologists in recent years is that of cognitive-behavioral modification. The major use of cognitive behavioral modification procedures with children has involved the training of self-control skills and strategies, especially with hyperactive, impulsive and aggressive children. A consistent theme in the research literature is that, although the approach produces encouraging results, evidence for the generalization of such treatment effects across settings and over time is equivocal. Best results are obtained when deliberate teaching for generalization is included in the program. A third area of research which is receiving increasing attention is that of improving academic learning through the teaching for transfer of cognitive strategies to academic subjects such as reading, writing, and mathematics. The consistent findings from this research are that students' academic learning abilities are improved by being taught to transfer general cognitive functioning skills and strategies to learning within these subject areas.

2.3.18 Training of Strategies for Learning

Studies of cognitive training appear to have a common component. Typically, subjects are taught how to use some systematic approach to problem-solving regardless of whether cognitive development, learning abilities, or cognitive-behavioral modification is being addressed. However, various studies differ substantially in the amount of information provided to the subject. Campione, Brown, and Ferrara (1982) have identified three types of strategies used in the training studies: blind training strategy, informed training strategy, and self-control training strategy.

2.3.19 In blind training, subjects are induced to use a particular strategy without understanding its significance. It has been found that such blind training fails to affect maintenance or generalization of the strategy (Green, 1974; Murphy & Brown, 1975). While such training may lead to enhanced recall on the tasks involved, it has been found that subjects do not use the strategy voluntarily, nor do they transfer the strategy to other similar learning situations.

2.3.20 In informed training, subjects are both encouraged to use a strategy and given some information concerning the significance of the activity. Examples of such training include subjects being taught to rehearse and given feedback concerning their improved performance (e.g., Kennedy & Miller, 1976) or provided with rehearsal training in multiple contexts so that they may realize the usefulness of the strategy (e.g., Belmont, Butterfield, & Borkowski, 1978). According to Campione and Brown (1977, 1978), such training is necessary if subjects are to make widespread use of instructed activities.

2.3.21 Self-control training has been used in recent years to attempt to identify the processes responsible for flexible use of learning routines. In this technique, subjects are instructed in the use of a strategy, and then taught how to use, to monitor, to check, and to evaluate that strategy (e.g., Brown, 1978; Brown & Campione 1978). According to researchers using this technique, the use of such higher-level, general overseeing functions is determined, at least in part, by metacognitive and executive functioning (Brown, 1978; Brown & Campione, 1978). They also contend that such functions are routinely used by effective learners, and play a major role in transfer which is essentially identified as strategy choice and execution.

2.3.22 In this training of strategies for learning, advocates of the use of computers in instruction also contend that this modern technology has application in cognitive education. One such approach involves the use of LOGO, a computer language program developed at the Massachusetts Institute of Technology and

popularized by Seymour Papert (1980). Papert argues that the capabilities of this computer language are ideally suited for supporting the development of strategies for improved cognitive processes.

- 2.3.23 The version of LOGO now in use on microcomputers permits the user to direct a "turtle" around the video monitor to create graphic designs. The language contains a small set of primitives, i.e., commands, which can be combined into more complex procedures by the user.

Papert (1980) contends that the LOGO experience permits students to learn more than just a computer language. Instead, the LOGO experience is intended to create an "environment for learning" in that it is designed to facilitate the learning of powerful ideas, skills, and heuristics which transcend the immediate environment and which can be applied in other problem-solving situations. In particular, Papert argues that LOGO lends itself to supporting the development of certain learning strategies and, through them, to the development of more efficient cognitive functioning. One such strategy is the breaking of problems into manageable sub-problems. Another is means-end analysis which requires systematic planning of action to achieve goals. A third important strategy developed through the LOGO experience is debugging. This is the process through which solutions to problems can be successively refined. Finally, Papert argues that LOGO develops in the student a more positive attitude toward errors. Students come to recognize that programming errors are not only unavoidable but are useful in providing information. This would imply that students should learn not to be negatively affected by errors.

- 2.3.25 Since its development, many claims have been made for the generalizeability of skills developed in the LOGO learning environment. Krassnor and Mitterer (1984), in a review of the research on such generalizeability, have observed that most of the supportive evidence is anecdotal (e.g., Goldenberg, 1980; Lawler, 1980; Papert, Watt, diSessa, & Weir, 1979; Weir & Emmanuel, 1976). These reviewers identified only a small number of studies (e.g., Chait, 1978; Howe, O'Shea, & Plane, 1979; Statz, 1973) which provide empirical evidence relevant to Papert's claim that learning LOGO produces general effects. As a result, they conclude that the LOGO literature "merits considerable criticism from an experimental point of view" (Krassnor & Mitterer, 1984, p.137)

- 2.3.26 Notwithstanding these concerns, Krassnor and Mitterer (1984) have identified a number of additional factors relevant to the potential of LOGO for facilitating cognitive development. It is a highly motivating agent for encouraging students to engage in such learning activities (see also, Michayluk & Yackulic, 1984;

Papert, 1980; Stowbridge & Kugel, 1983; Watt, 1982). In particular, it has been found to be especially motivating for academically underachieving students. Krassnor and Mitterer suggest that this motivational component provides LOGO with a special advantage over other methods of teaching problem-solving. In addition, the programming environment is characterized by immediate feedback and total user control, and therefore should allow underachieving students to develop a sense of mastery and competence (cf. Bronson, 1974)

- 2.3.27 The LOGO environment also provides for small group experience since there are usually two or three students working at the same terminal. This should encourage students to cooperate with peers in the completion of small group projects, and should allow a student opportunity to learn by observing the process and outcomes of others' actions (cf. Bandura, 1977). It should also encourage the development of clear, complete communication (Feuerstein et al., 1980) since the small group situation would require each student to communicate effectively with peers. Piaget has also noted the importance to cognitive development of negotiation in social interaction since this facilitates the growth of decentration and perspective-taking skills (Piaget & Inhelder, 1969).
- 2.3.28 Krassnor and Mitterer (1984) also suggest that there is evidence to support a position that LOGO may be most effective as an instructional tool for facilitating cognitive development provided students are at least at the transitional stage to Piagetian formal operational thought. Papert (1980) has concluded that, since LOGO offers a student a way of concretizing the abstract, it should be a very powerful agent for the development of formal operational thought processes. Folk (1972) has suggested it may be possible that only children who have reached the formal operations stage would be capable of fully utilizing LOGO for cognitive development purposes. Folk argues that at least some of the general problem-solving heuristics involved in the LOGO experience would require formal operational thought capability. Krassnor and Mitterer (1984) propose that both Papert's and Folk's positions would indicate that an optimal age of LOGO instruction may be, as a minimum, the age of 12 years since this represents the usual onset of the formal operations stage (Inhelder & Piaget, 1958).
- 2.3.29 In conclusion, it would seem reasonable to suggest that it would be necessary to adapt the LOGO environment in order to facilitate transfer with underachieving students. If transfer is to take place, the research has shown that poor learners need to be taught both specific and general skills in a given content domain (cf. Brown, Bransford, Ferrara, & Campione, 1983). Without such teaching, students with limited language, spatial, and mathematical skills would have limited possibilities for

going beyond immediate programming modes. Elementary computer literacy could be achieved by such students. However, relatively little generalizable problem-solving skill would be realized without explicit teaching for transfer (see also, Stowbridge & Kugel, 1987). Specifically, Krassnor and Mitterer recommend that teachers should "explicitly emphasize how the skills learned in LOGO are relevant for problems outside the turtle world, how children may recognize appropriate similarities among problem-types, and how LOGO skills may be adapted for other types of problems" (Krassnor & Mitterer, 1984, p. 141).

- 2.3.30 A study by Michayluk and Yackulic (1984) has tested with Native students the potential of LOGO programming for positively affecting cognitive strategies. Fifteen Native education students were selected for a project at the University of Saskatchewan. Students were given a brief introduction to LOGO and were encouraged to work individually through the LOGO Manual. The ten hours each student spent on the project were directed towards completion of four tasks: acquisition of skills in LOGO, completion of a game project, completion of a procedure involving LOGO, and completion of an original graphics project. In order to monitor the potential impact of LOGO, the Logical Reasoning Test (Burney, 1974) was administered to the students both prior to and on completion of the LOGO project, with time between testing being eleven weeks. No control group was used in the study.
- 2.3.31 Ten students completed the full program and became more proficient in their reasoning and thinking ( $p < .05$ ). The researchers do not report reason for dropout by one-third of the subjects, although it is noted that some of these students complained that their culture did not prepare them for the technology involved.
- 2.3.32 While the experimental methodology used in this study is inadequate to evaluate the potential of LOGO for positively affecting problem-solving strategies in Native students, it does indicate potentially important issues. The use of the standard LOGO Manual meant that no attempt was made to relate the LOGO learning experience to factors within the subjects' own culturally-influenced learning experience. It is possible that this may have affected the subjects' belief that their culture had not prepared them for the technology involved. Further, the use of the structured Manual may have restricted subjects' interpretation of the potential of the LOGO experience to explore the design and construction of images and patterns from their own cultural milieu.

2.4. Summary of Training Approaches

- 2.4.1 Cognitive-modifiability researchers have developed a distinctive, organized intervention program, Instrumental Enrichment, for facilitating development of specific cognitive functions in underachieving adolescents. The development of each function is addressed through sets of paper-and-pencil exercises designed to be as content-free as possible. Extensive training is required of all teachers involved in implementing the program.
- 2.4.2 Information-processing theorists have concentrated primarily on training programs aimed at developing critical cognitive strategies in children. These programs have included training of strategies for cognitive functioning and transferring these to effect cognitive-behavioral modification and improved academic learning abilities in subject areas such as reading, writing, and mathematics. The LOGO computer language program has been found to possess a number of attributes of potential importance for effecting cognitive modification.

2.5. Assessment of Cognitive Functioning

- 2.5.1 Contemporary philosophies of education suggest that instruction should be designed to match the cognitive functioning abilities of the student. In order to realize such an objective, a proper assessment of those abilities is required. The search for effective methods of such assessment has occupied the attention of many psychologists, and a substantial body of literature has been made available on the subject. While cognitive psychologists have utilized a number of approaches to assessment (for a review, see Stenberg, 1981b), the use of two models, in particular, is being stressed in the current literature. These models are the psychometric model and the dynamic assessment model.
- 2.5.2 Psychometric tests are explicitly designed so that they will provide the same environment for each subject. In short, a standardized psychometric test is constructed, administered, and scored according to prescribed rules. It is believed that by using such standard procedures, direct comparisons between individuals and between groups are possible. The major issue in contemporary literature concerning psychometric tests centres around the interpretation made of the information provided by them. It is commonly held that the concept of intelligence held by the psychometrics is that of an entity, measured by a score obtained from a test. Vygotsky (1978), however, has argued that psychometric tests measure only the level of development of a child's mental functions that have been established as a result of certain, already completed, developmental cycles.

2.5.3 Despite the shortcomings in psychometric testing identified by many researchers, the point made by Campione and his associates (Campione et al., 1982) seems to be of particular importance. Psychometric tests can provide a useful indication of cognitive development that has occurred to a given moment in an individual's life. However, given the relationship between culture and cognition, it becomes evident that not all psychometric tests or testing procedures may be appropriate for use in various cultural situations.

2.5.4 The fact that certain conventional psychometric tests may tend to discriminate against persons who are not members of western, urban-middle-class cultures has been recognized for some time (Anastasi & Foley, 1949). West and MacArthur (1964) have acknowledged that, with Canadian Native people, the search for appropriate assessment instruments which are relatively independent of specific environmental experience is of special importance. This search by many psychologists for more appropriate measures of cognitive functioning in cross-cultural situations resulted in identification of a "culture-reduced" test.

2.5.5 West and MacArthur (1964) reported an evaluation of selected tests for two samples of Metis and Indian children. An experimental battery of selected tests was chosen for a factor analytic study. Four criteria were used to evaluate each test. These were:

1. A cross-cultural test should show less difference between cultures in a bi-cultural administration than do conventional verbal tests;
2. It should contain items that could be solved in any language or mode of expression and which are likely to be as familiar and useful for one cultural group as another;
3. It should show substantial relationship to school achievement; and
4. It should show a significant relationship with other well-known and commonly-used measure of intelligence.

2.5.6 As a result of this research, MacArthur has concluded that the Raven's Progressive Matrices (Raven, 1956, 1958) is the most suitable test for cross-cultural assessment of cognitive ability (MacArthur, 1968). He offers three reasons for this decision:

1. The items form something of an age-scale sampling in the development of human cognition, starting with perception-dominated items, and proceeding through reversible concrete operations, to propositional or formal operation;

2. They use as stimuli symbols which, though dependent on learning, are likely to be learned in a variety of cultures;
3. The arrangement of items forms a crudely-programmed sample of learning-on-the-spot (MacArthur, 1968, pp. 121-122).

- 2.5.7 The dynamic assessment approach to cognitive assessment is used primarily to identify particular functions or strategies which may be underdeveloped. It is also used to determine the nature of training required for cognitive modifications (Feuerstein et al., 1979).
- 2.5.8 Structural-modifiability theorists assess cognitive modifiability by pretesting individual subjects to establish their manifest, or base line, level of functioning (Feuerstein, Miller, & Jensen, 1980; Feuerstein, Rand, & Hoffman, 1979). Modifiability is then assessed by giving the subject instruction in solving problems which they were initially unable to solve, and then evaluating the subject's ability to benefit from instruction.
- 2.5.9 In contrast to Feuerstein, the information-processing researchers place more emphasis on the patterns of errors made and on the use of graduated aids in their assessment procedure (e.g., Brown & Barclay, 1976; Brown & Campione, 1977; Brown, Campione, & Day, 1981). A typical testing session consists of the initial presentation of a test item, with the individual examinee being asked to solve the problem independently. If failure occurs, the examiner progressively adds clues for solution, and assesses how much additional information is needed to solve the problem. Once solution is reached, another version of the original task is presented. Transfer to this novel item is considered by calculating whether or not the subject requires fewer cues in order to reach solution. The assessment process is also considered as providing information concerning the subject's ability to profit from adult, or peer, assistance.
- 2.5.10 The dynamic assessment model developed by the structural-modifiability theorists has been used, in a clinical situation, with Navajo Indian children (Jensen, 1985). Results indicate that both the approach and the specific tests were appropriate for use with this group. Similarly, a study by Carnew (1983) found both the tests and the approach to be appropriate for Cree Indian adolescents. No reports are available to indicate the appropriateness of the information-processing approach for Native subjects.

### 3.0 RATIONALE, HYPOTHESES, AND DESIGN OF THE STUDY

#### 3.1. Framework

3.1.1 The question addressed in this study concerned the potential usefulness of a cognitive education intervention approach to improving learning abilities of underachieving Native adolescents. The specific variables considered were (1) the manner in which this approach may affect cognitive development, (2) academic learning, (3) attitudes towards and interest in academic subjects, and (4) teacher attitudes towards such students. The review of the structural-modifiability and information-processing theorists' positions suggests that all humans have the capacity to modify the structure of their cognitive processing. Both positions emphasize the potential effectiveness of training in assisting adolescents to redirect their developmental process.

3.1.2 The training methods used by the various researchers reflect some common approaches, but also identify some substantial differences. In general, the researchers agree that, in order to attain both durability and generalization of training, it is necessary to achieve improvement at the executive, or self-monitoring, level of cognition. The structural-modifiability theorists contend that this is best accomplished through facilitating improvement of the various cognitive functions involved at each phase of the mental act. In contrast, the information-processing theorists argue that such improvements are most effectively accomplished through training in the use of specific learning and metacognitive strategies. Instead of restricting one's methods to either of these considerations, it would seem that an effective method might be to combine both into one comprehensive approach. In doing so, one could utilize the teaching of strategies to achieve more effective cognitive functioning. In summary, this comprehensive approach to assisting underachieving Native adolescents would attempt to facilitate further development of cognitive processes by improving under-developed cognitive functions through the teaching of efficient performance strategies.

#### 3.2. Assessment of Cognitive Functioning Abilities

3.2.1 The literature on the use of the psychometric assessment model with Native adolescents suggests that caution has to be taken in the selection of appropriate tests. The research by West and MacArthur has determined that culture-reduced tests are reasonably appropriate. However, as the critics of the psychometric model have pointed out, the approach is normally used only to assess the degree to which development has already occurred and, as such, is not used to provide information required for determining aspects of cognitive development which need attention in an intervention program. It does, however,

have the distinct advantage of being an efficient approach to group assessment.

3.2.2 The dynamic assessment model of the cognitive-modifiability theorists centres on identifying specific areas of cognitive functioning in which one must intervene in order to bring about the desired modification. The model, however, is generally used in clinical situations where individual subjects are being assessed. This presents a particular problem for researchers interested in investigating large numbers of underachieving adolescents where the time and resources required for individual assessments is prohibitive.

3.2.3 The information-processing model of assessment also is used primarily with individuals. It therefore presents problems similar to the structural-modifiability approach. However, the model does suggest a process which may be effective in combining the psychometric model and the dynamic assessment model by analyzing the patterns of errors identifiable from subjects' performance on cognitive tasks from psychometric model could be taken advantage of, and the results used to provide information on the particular underdeveloped cognitive functions and strategies needed for the design of an effective intervention program.

### 3.3 Program

3.3.1 While evaluation of the potential effectiveness of the various training programs for Native adolescents is made difficult by the lack of experimental research with this population, nevertheless, research findings from other populations are appropriate for consideration in an exploratory study of this nature.

3.3.2 The Instrumental Enrichment program developed by the structural modifiability theorists presents a structured and formalized method of training. However, a number of its basic tenets raises some questions concerning its appropriateness for use in toto with Native adolescents.

3.3.3 The Instrumental Enrichment program requires that subjects complete a structured set of pencil-and-paper exercises. In contrast, the information-processing theorists rely on a variety of training methods, one of which can be use of the LOGO computer language program. In the context of a program for underachieving Native adolescents, the attributes of such modern technology would appear to merit serious consideration. It has been proven to be a highly motivating agent and, as such, its novelty and appeal should be more effective than the more

traditional pencil-and-paper approach in encouraging and sustaining involvement in a cognitive education program. In contrast to the Instrumental Enrichment approach, students may use LOGO as an agent for learning with a minimum of structure being imposed. This should provide a more flexible and adaptive approach to training. Furthermore, the LOGO programming environment provides for immediate and constant feedback to students, a process which is virtually impossible for even the most highly competent teacher. Finally, in contrast to Instrumental Enrichment, the LOGO environment allows for total control by the user. This feature should encourage a sense of mastery and competence in the Native adolescents. Unlike their previous experiences in formal learning, the LOGO environment should help them to feel powerful and successful. As a result, it should be more effective in overcoming the sense of helplessness, believed to be characteristic of such students, than would the pencil-and-paper activities of the Instrumental enrichment program since these may well be associated with previous learning.

- 3.3.4 Despite these potentially positive aspects of the LOGO experience, the research by M. Syluk and Yackulic (1984), reviewed earlier, indicates that care must be taken to ensure that the Native students can relate this technology to their own cultural environment. This should be readily accomplished by initially encouraging construction of traditional and contemporary Cree Indian artistic designs as the content for training in the use of effective strategies for efficient cognitive functioning.
- 3.3.5 A second tenet of the Instrumental Enrichment program is that the instruments should be content-free. The structural-modifiability theorists argue that school subject-matter learning cannot be molded easily into a suitable vehicle for training cognitive development. In contrast, the information-processing theorists believe that the content material of the training program is secondary to the training philosophy which underlies the program, and that it is possible to train cognitive functioning skills within the domain of actual school tasks. They have used subject-matter such as reading, writing, and mathematics as a vehicle to train the strategies they consider necessary for effective cognitive functioning.
- 3.3.6 The basic construct at issue in this matter between these two positions is the selection of an effective approach to teaching for transfer or generalization of the principles being learned in the program. In the context of academically underachieving Native adolescents, it would seem reasonable to assume that transfer of cognitive training to school achievement will be most likely to occur if the training involves school-related content such as that found in reading, writing, and mathematics.

Furthermore, in view of the evidence which suggests that such underachievers may be characterized by a state of "learned helplessness", it would seem to be most appropriate to demonstrate that use of efficient and effective cognitive functions and learning strategies can affect their ability to achieve success in school. If this is accomplished, students' attitudes towards these subjects, which initially may be found to be negative as a result of past experiences, should be improved as well.

- 3.3.7 Consideration of relevant literature suggests that a cognitive education approach is a feasible framework in which to explore a method of assisting academically underachieving Native adolescents. Based on principles and ideas extracted from this literature, and on considerations of practices believed to be potentially appropriate for this population, the procedures followed in this study involve (a) facilitating development of cognitive processes by (b) development of cognitive functions through the teaching of performance strategies using (c) the LOGO computer language, cultural content, mathematics, reading and writing, and everyday life experiences as sources to which these strategies can be transferred. The remainder of this chapter describes the actual design of the study.

#### 3.4

#### Hypotheses

As a result of the planned intervention, it was hypothesized that:

- H1 There would be a significant difference between the manifest level of cognitive functioning as assessed by subjects; performances on pretests and the level of cognitive functioning as assessed by subjects' performances on posttests.
- H2 There would be a significant difference between subjects' attitudes towards mathematics and language arts as assessed by responses on pretests and on posttests.
- H3 There would be a significant difference between the level of academic functioning in mathematics, reading, and writing as assessed by subjects' performances on pretests and on posttests.
- H4 A significant difference would be found between the control group and the experimental group in respect to attendance.

### 3.5

#### Subjects

3.5.1 Subjects involved in this study were Native Cree Indian adolescents from Alberta. Initially, 69 subjects were selected to participate in the preliminary assessment phases for the purpose of identifying patterns of underdeveloped cognitive functions. These subjects were selected on the basis of the following criteria:

1. Being identified by teachers as educationally underachieving, i.e., characterized by age-grade retardation of one or more years;
2. Being identified by teachers as demonstrating poor motivation for formal school learning; and
3. Characterized by a history of irregular school attendance.

Of this original group, 36 subjects were male and 33 subjects were female. Average age of this total group was 14.90 years.

3.5.2 In the two-month intervening period between the initial selection and the beginning of the intervention program, 30 of the original subjects were deleted from the initial group for reasons as follows:

Subjects who ceased attending school for unknown reasons;

Subjects who experienced family problems resulting in withdrawal from school;

Subjects who experienced extended illness requiring a long period of absenteeism;

Subjects who attended too irregularly for consideration;

Subjects who were expelled from one school; and

A subject who was transferred to a different program by a participating school.

These subjects were replaced in the study by 17 alternative subjects selected on the same criteria as the original group. This resulted in a final group of 56 subjects taking part in the experimental study.

3.5.3 Average age of this final group of subjects was 14.71 years. Of the group, 28 subjects were male and 28 subjects were female. This final group of subjects was assigned to experimental or control groups on the basis of criteria described below.

### Experimental Subjects

- 3.5.4 From the final group of 56 participating subjects, 38 subjects served as experimental subjects. Of these, 18 students were male and 20 students were female. Mean age of experimental subjects was 15.0 years.
- 3.5.5 All experimental subjects had previously been identified by their schools as requiring some form of special assistance in order to cope with formal learning and, as a result, had been placed in a special class by each of the four institutions involved.

### Control Subjects

- 3.5.7 Out of the final group of participating subjects, a total of 18 students served as control subjects. Of these, 10 subjects were male and 8 were female. The mean age of the control subjects was 14.1 years.
- 3.5.8 Control subjects were selected on the basis of being already placed in regular school classes, i.e., unlike the experimental subjects, they were not assigned to special classes by their respective educational institutions. These control subjects were drawn from Grades 7 and 8 in two schools.

## 3.6

### Instrumentation

The following tests were used in this study for assessment purposes.

### Tests of Cognition

1. Raven's Coloured Matrices, sets A, Ab, B (Raven, 1956, 1962);
2. Raven's Progressive Matrices, sets C, D, E (Raven, 1958);
3. Learning Potential Assessment Device (L.P.A.D.), Variations I (Feuerstein, 1980);
4. Learning Potential Assessment Device (L.P.A.D.), Variations II (Feuerstein, 1973a);
5. Representational Stencil Design Test (R.S.D.T.) I (Feuerstein, 1973b);
6. Representational Stencil Design Test (R.S.D.T.) Parallel form (Feuerstein, 1973c).

### Academic Tests

1. Canadian Tests of Basic Skills, Multilevel Edition/Levels 9-14, Form 5 (King, 1981);
2. Canadian Tests of Basic Skills, Multilevel Edition/Levels 9-14, Form 6 (King, 1981);

### Attitudes Test

1. School Subjects Attitudes Scales (Nyberg & Clarke, 1983).

### Computer Awareness Questionnaire

In addition to the above tests, a Computer Awareness Questionnaire was administered to all subjects during the preliminary phases of the study.

## 3.7 Description of Tests

### .7.1 Raven's Coloured and Progressive Matrices

- 3.7.1.1 Raven's Coloured and Raven's Progressive Matrices can, as a whole, be described as a "test of observation and clear thinking" (Raven, 1956, p.3). They represent an unspeeded, non-verbal test of general cognitive ability and assess a person's capability to:

apprehend meaningless figures presented for his observation, see relations between them, conceive the nature of the figure completing each system of relations presented, and, by doing so, develop a systematic method of reasoning. (Raven, 1960, p.1)

According to Raven (1956), the tests should indicate clearly whether a person is, or is not, capable of forming comparisons and reasoning by analogy. If the person is incapable of these processes, the tests should show to what extent capability exists for organizing spatial exceptions into systematically related wholes.

- 3.7.1.2 The Coloured Matrices, Sets A, Ab, B, can be used to show "the degree to which [a person's] capacity for abstract thinking has developed and may reasonably be expected to develop" (Raven, 1956, p.24). The three sets of twelve problems are arranged to assess the main cognitive processes of which children under twelve years of age are usually capable. The scale as a whole, i.e., Coloured Matrices and Standard Progressive Matrices, is designed to assess, as accurately as possible, mental development up to intellectual maturity.

- 3.7.1.3 The Raven's Matrices has a test-retest reliability, varying with age from .83 to .93. Because of its culture-reduced content it has been used extensively in cross-cultural research. The literature relevant to this has been discussed above. Procedures for test administration are detailed in the Guidebook accompanying the test.

3.7.2 Feuerstein's Learning Potential Assessment Device (L.P.A.D.), Variations I and II

- 3.7.2.1 Feuerstein's Learning Potential Assessment Device (L.P.A.D.) Variations I consists of sets of six variations on five Raven's Coloured Progressive Matrices: B-8 to B-12. the L.P.A.D. variations II is based on tasks from Raven's Standard Progressive Matrices, sets C, D, and E. It consists of sets of ten to fifteen variations each of items C-7, C-8, D-12 and E-12 of the Standard Progressive Matrices. It also contains one more advanced item. The task is to complete the pattern by selecting an appropriate response from among eight given alternatives. Items within each series become progressively more different from the original task (Feuerstein, Rand, & Hoffman, 1979).

The specific purposes of the test are to assess the modifiability of specific processes of thought, to observe these processes of change under direct teaching of appropriate principles, and to prescribe remedial measures (Feuerstein et al., 1979).

- 3.7.2.2 Feuerstein does not provide reliability and validity test data for the instruments in the Learning Potential Assessment Device. He acknowledges that the conventional assessment instruments, such as Raven's Matrices, do show statistically high reliability and validity values. He contends that the more powerful an intervention strategy, the less the product of intervention will be related to the initial level of functioning of the individual. He argues that "the validity of a test can only be a reflection of the stability and fixity of the cognitive behavior of the individual subjected to it" (Feuerstein et al., 1979, p. 326). Within such a construct, one should expect low correlations with the initial results following a change being induced in the individual by a specific intervention since, in essence, stability has been disrupted in the process. Feuerstein and his colleagues report clinical-anecdotal and statistical follow-up studies which have demonstrated a relatively high validity and reliability for the techniques and instruments they have developed (Feuerstein et al., 1979, pp. 127-227).

### 3.7.3 Representational Stencil Design test (R.S.D.T.) I and Parallel Form

3.7.3.1 The Representational stencil Design Test (R.S.D.T.) is a further component of Feuerstein's Learning Potential Assessment Device (L.P.A.D.). Adapted from the Stencil Design Test of Grace Arthur (1930), its purpose is to assess the capacity of the subject to develop internalized problem-solving behavior (Feuerstein et al., 1979). Arthur's original test required the examinee to construct a specified design by manually superimposing appropriate stencils one upon another. Contending that this process allowed for a trial-and-error problem-solving process, Feuerstein redesigned the test to remove opportunity for actual motorical manipulation of the stencils. Eighteen stencils, differing in colour and form, are provided for the subject on a chart. The subject is required to reconstruct 20 designs in either the R.S.D.T. I or Parallel Form Test by selecting stencils from the chart and mentally "superimposing" these on each other. In order to do so, the subject has to represent to himself or to herself the resulting design, and to keep this internally constructed representation stable while proceeding with further steps. The identifying number of each stencil is recorded on a separate answer sheet in order of placement. A score of one point is given for each correct stencil recorded in proper order. No score is given if a correct stencil is identified in wrong order.

3.7.3.2 Administration of the test consists of two phases: training and testing. Training is provided through use of a set of 20 simple tasks aimed at preparing the examinee for the test. The training phase assists the examinee to become acquainted with the individual stencils printed on the chart and especially with their location, the identifying number for each stencil, and their proper use. Following this, the examinee is then presented with the actual test.

### 3.7.4 Academic Tests

3.7.4.1 The Canadian Tests of Basic Skills (C.T.B.S.) (King, 1981) are academic achievement tests designed to "provide for comprehensive and continuous measurement of growth in the fundamental skills: vocabulary, reading, the mechanics of writing, ... and mathematics" (King, 1982, p.3). The Multilevel Edition/Levels 9-14 used in this study represents a continuous scale from low-level Grade 3 to superior Grade 8 performance (King, 1982). There are two alternate forms in this edition of the Multilevel Battery: Form 5 and Form 6. In normal school-related use, raw scores are converted to grade equivalents, or standard scores. However, in this study, raw scores are used to assess variations in performances on these tests between pretesting and posttesting of subjects.

- 3.7.4.2 The author reports that reliabilities vary from test to test and from grade to grade. Internal consistency reliability coefficients range from .87 to .96 while composite reliability is .97 to .98 for all grades (King, 1982). The Administrator's Manual accompanying the test provides detailed instructions for administering the test. Essentially, the administrator provides sufficient information to ensure that subjects understand the tasks required of them in the tests.

3.7.5 Attitudes Test

- 3.7.5.1 The School Subjects Attitudes Scales were developed during 1978 and 1979 by V.R. Nyberg and S.C.T. Clarke of the University of Alberta. Their purpose in developing these Scales was to make available an instrument for measuring students' attitudes towards school subjects. The Scales were developed as group (classroom) measures of students' attitudes for Grades 5 through 12, with norms identified for most subjects from Grades 5 through 9.

- 3.7.5.2 The instrument contains twenty-four descriptive word pairs, with five response positions available for each word pair as in the following example:

	very much	a bit	neither	a bit	very much	
nice	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	awful

The first eight of these word pairs define the evaluative factor, the next eight define the usefulness factor, while the final eight word pairs define the difficulty factor (Nyberg & Clarke, 1983). Students are asked to indicate the response position, for each descriptive word pair, which most accurately describes how they feel about a particular subject. In this study, subjects were asked to complete the Scales for mathematics and language arts (reading and writing).

- 3.7.5.3 The authors report that reliability coefficients vary, among the three scales. Values of the coefficients range from .61 to .86 with most being in the .700 to .799 range (Nyberg & Clarke, 1983, p.6). On four different comparisons, the Scales have been found to be valid. The comparisons included expert opinion, student preferences, sex differences, and cultural differences (Nyberg & Clarke, 1982).

- 3.7.5.4 In scoring the Scales, each response has a positive value ranging from 1, representing the most negative attitude, to 5, representing the most positive attitude. The Administrator's Manual, available with the Scales, provides norms for Grades 5 through 12 in most school subjects. These norms provide an adjustment for time of year (at the beginning, in the middle, or at the end of a course) and for differences in the ratio of the sexes in the class. Scores can also be interpreted in an absolute sense. With each scale consisting of eight word pairs, the score range for each scale is 8 to 40 (Nyberg & Clarke, 1982). A "neutral" attitude corresponds to a score of 24. An evaluative score above 24 indicates that the subject is liked. A usefulness score above 24 indicates that the student finds the subject useful. A difficulty score above 24 indicates that the student finds the subject difficult. Similarly, scale scores below 24 indicate a dislike for a subject, that it is not useful, or that it is easy. In this study, scores were interpreted in the absolute sense.

### 3.7.6 Computer Awareness Questionnaire

A computer Awareness Questionnaire (see Appendix A) was designed and administered to all subjects in the initial testing phase. The purpose of this Questionnaire was to determine subjects' familiarity with computers and with typewriters prior to participation in the program. The first question required subjects to indicate if they had ever used a computer. Those who responded positively were then requested to answer six questions to determine manner and frequency of use. A seventh question solicited similar information in respect to typewriters in order to determine subjects' prior familiarity with the keyboard. Six response positions were provided for subjects as in the following example:

Playing computer games	No	Yes	Once a Year	Once a Month	Once a Week	Almost Daily
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A value of 0 was assigned if subjects responded negatively. If response was positive, the following values were assigned to the frequency of use indicated by students:

Once a Year:	1 point
Once a Month:	2 points
Once a Week:	3 points
Almost Daily:	4 points

Results were calculated and reported as percentages.

Figure 3.1  
Summary of Research: Preliminary Phase

Phase	Activities
Preliminary	<ol style="list-style-type: none"><li>1. Obtained permission to conduct study.</li><li>2. Acquisition of equipment.</li><li>3. Identification of underdeveloped cognitive functions.</li><li>4. Identification of subjects' awareness of computers.</li><li>5. Identification of cognitive functions required for successful learning in mathematics and in language arts at the junior high school level.</li><li>6. Program development.</li><li>7. In-servicing of cooperating teachers.</li></ol>

3.8 Procedure for Development and Implementation of the Study

3.8.1 Development and implementation of the study was conducted in three phases: Preliminary Phase, Introductory Phase, and Full Implementation Phase. Figures 3.1 to 3.3 provide an outline of the major activities undertaken in each phase. These activities are described in greater detail in the following pages.

3.8.2 Permission

- Permission to conduct this study was obtained from all relevant sources. A sample of the letter sent to parents/guardians is included in Appendix B.

3.8.3 Identification of Underdeveloped Cognitive Functions

3.8.3.1 An initial assessment was undertaken to identify underdeveloped cognitive functions. Raven's Coloured Matrices (sets A, Ab, B), Raven's Progressive Matrices (sets C, D, E) and the Representational Stencil Design Test (R.S.D...) I were group administered in this order, following procedures specified by the tests' designers as described earlier in this chapter. These tests were administered to the original 60 subjects by F. Carnew of the research team.

3.8.3.2 Following this, the students' response sheets for each of the three tests were provided to an independent expert panel. This panel consisted of two psychologists experienced in analyzing such data for the purpose of identifying underdeveloped cognitive functions. Instructions to the panel included the requirement to restrict their consideration of underdeveloped cognitive functions to the list of cognitive functions provided by Feuerstein et al. (1980). The panel also provided examples of the evidence found to support their decisions. These examples are also summarized in Figures 3.4 to 3.6.

3.8.4 Identification of Subjects' Computer Awareness

The Computer Awareness Questionnaire was group administered to all participating subjects directly following the administration of the tests assessing cognitive functioning. Results of this questionnaire are reported below.

Figure 3.2

Summary of Research: Introductory Phase

Pha	Activities
Introductory	<ol style="list-style-type: none"><li>1. Experimental subjects taught introductory LOGO Computer Language Program Component.</li><li>2. Ongoing support provided to cooperating teachers.</li><li>3. Assessment of manifest level of cognitive functioning of control and experimental subjects.</li><li>4. Assessment of attitudes towards mathematics and language arts by control and experimental subjects.</li><li>5. Assessment of manifest level of academic functioning in mathematics and language arts of control and experimental subjects.</li><li>6. Interpreting and reporting back of cognitive assessment results to all subjects.</li></ol>

Figure 3.3

Summary of Research: Full Intervention Phase

Phase	Activities
Full Intervention	<ol style="list-style-type: none"><li>1. Extended LOGO Computer Language Program Component, Writing Component, Reading Component, and Mathematics Component taught to experimental subjects (10 weeks).</li><li>2. Provision of ongoing support to each experimental group.</li><li>3. Maintenance of involvement with control groups.</li><li>4. Final assessments of control and experimental subjects: cognition, academic, and attitudes.</li><li>5. Final interviews with teachers of experimental subjects.</li><li>6. Final interviews with school administrators, control subjects.</li><li>7. Final reporting back of all assessment results to all subjects (control and experimental).</li></ol>

Figure 3.4

Underdeveloped Cognitive Functions Identified by Independent  
Expert Panel from Analysis of Results of Initial  
Cognitive Tests: Input Phase

Underdeveloped Cognitive Functions	Examples of Evidence
Blurred and sweeping perception	Strong tendency to use perceptual closure, especially as tasks became more complex.
Unsystematic exploratory behavior	Lack of spontaneous comparison. Lack of hypothesis testing.
Underdeveloped precision and accuracy in data gathering	Consistent omission of at least one crucial piece of information. Lack of precision in identifying number of elements involved in tasks.
Underdeveloped capacity to consider all relevant sources of information at once	Consistent ignoring of key sources of information. Too much reliance on perceptual cues.
Underdeveloped ability to orient spatially	The variable "position" not systematically taken into account. Failure to establish relational information.
Inadequate verbal tools for labelling	Assumed to exist, based on panel's experience with similar students.

Figure 3.5

Underdeveloped Cognitive Functions Identified by Independent  
Expert Panel from Analysis of Results of Initial  
Cognitive Tests: Elaboration Phase

Underdeveloped Cognitive Functions	Examples of Evidence
Underdeveloped appreciation of need for logical evidence	Persistent tendency for perceptual, rather than conceptual, approach to problem-solving.
Narrowness of the mental field	Obvious difficulties in dealing with comparisons requiring subtrac- tive processing. Reliance on sequential processing and neglect of simultaneous processing, especially in R.S.D.T. tasks.
Underdeveloped ability to project virtual relation- ships	Consistent failure to use rela- tional information.
Underdeveloped comparative behavior	Consistent tendency to compare on one dimension only. Consistent evidence of being influenced by one component, e.g., colour in R.S.D.T. and solid black in Raven's Matrices.
Difficulties with visual transport	Assumed to exist, based on panel's experience with similar students.

Figure 3.6  
Underdeveloped Cognitive Functions Identified by Independent  
Expert Panel from Analysis of Results of Initial  
Cognitive Tests: Output Phase

Underdeveloped Cognitive Functions	Examples of Evidence
Impulsive behavior in responding	Random responding consistently appearing when 4 or more stencils were required to complete R.S.D.T. tasks. Evidence of strategy, "When in doubt, select something seen before." Consistent tendency to select response that looked most complex.
Blocking	Avoidance of complex tasks. Consistent evidence of emotional distur- bance being caused by the more difficult tasks, especially in Raven's, sets D and E, and in R.S.D.T.
Difficulties with visual transport	Assumed to exist, based on panel's experience with similar students.

3.8.5 Identification of Cognitive Functions Required for Successful Learning in Mathematics and Language Arts at the Junior High School Level

3.8.5.1 Specific cognitive functions required for successful learning in mathematics and language arts at the junior high school level were identified by a second independent expert panel. This panel consisted of two teachers, experienced in teaching academic subjects at the junior high school level. In addition, both teachers were previously trained for, and experienced in, the implementation of programs designed to facilitate growth of cognitive functions, and particularly in the use of the Feuerstein et al. (1980) Instrumental Enrichment (IE) program. These teachers were instructed to restrict their consideration of required cognitive functions to the list provided by Feuerstein et al. (1980) and described above. The teachers were also instructed to continue the process of analysis until complete agreement on required cognitive functions was accomplished.

3.8.5.2 Following this analysis, the independent panel of teachers reported that, while competency by junior high school students in all of the cognitive functions listed by Feuerstein et al. (1980) was desirable, it was the opinion of the panel that some functions were of particular importance. This latter list identified those functions which, if underdeveloped, would most likely impair performance in mathematics and language arts. The findings of this expert panel of teachers are summarized in Figures 3.7, 3.8, 3.9.

3.9 Program Development

3.9.1 Selection of Cognitive Functions

3.9.1.1 In approaching the development of the actual intervention program, it was decided to concentrate primarily on the further development of the matrix of cognitive functions:

1. Identified by the expert panel of teachers as being of particular importance for efficient learning of mathematics and language arts at the junior high school level; and
2. Assessed by the expert panel of psychologists as being generally underdeveloped in the subjects.

Figure 3.7

Cognitive Functions of Particular Importance for the Learning  
of Mathematics and Language Arts at the Junior High School  
Level: Input Phase

Phase	Subject	Cognitive Functions
Input	Mathematics	Systematic exploratory behavior Precision and accuracy in data gathering Appreciation of constancy and conservation Ability to orient spatially Capacity to consider multiple sources of information at once
	Language Arts	Clear perception Adequate verbal tools and concepts; adequate encoding and decoding skills Precision and accuracy in data gathering Capacity to consider multiple sources of information at once

Figure 3.8  
Cognitive Functions of Particular Importance for the Learning  
of Mathematics and Language Arts at the Junior High School  
Level: Elaboration Phase

Phase	Subject	Cognitive Functions
Elaboration	Mathematics	Appreciation of need for logical evidence Breadth of the mental field Inferential, hypothetical thinking Strategies for hypothesis testing Summative behavior
	Language Arts	Accurate problem definition Breadth of mental field Planning Comparative behavior Projection of relationships to new situations Summative behavior

Figure 3.9  
Cognitive Functions of Particular Importance for the Learning  
of Mathematics and Language Arts at the Junior High School  
Level: Output Phase

Phase	Subject	Cognitive Functions
Output	Mathematics	Precision and accuracy in communicating one's responses Avoiding trial-and-error responding Avoiding impulsive responding Avoiding blocking
	Language Arts	Clear, complete communication Adequate verbal tools Precision and accuracy in communicating Avoiding impulsive responding Avoiding blocking

- 3.9.1.2 Specifically, the underdeveloped cognitive functions from this matrix to be addressed primarily were:

Input Phase: Clear perception; the ability to search for complete information;  
Planned, systematic exploration;  
Precision and accuracy in data gathering.  
Capacity to consider multiple sources of information at once;  
Ability to orient spatially; and  
Adequate verbal tools.

Elaboration Phase: Ability to appreciate the need for logical evidence;  
Breadth of the mental field;  
Ability to project virtual relationships;  
Comparative behavior; and  
Visual transport.

Output Phase: Ability to overcome impulsive behavior;  
Ability to overcome blocking; and  
Visual transport.

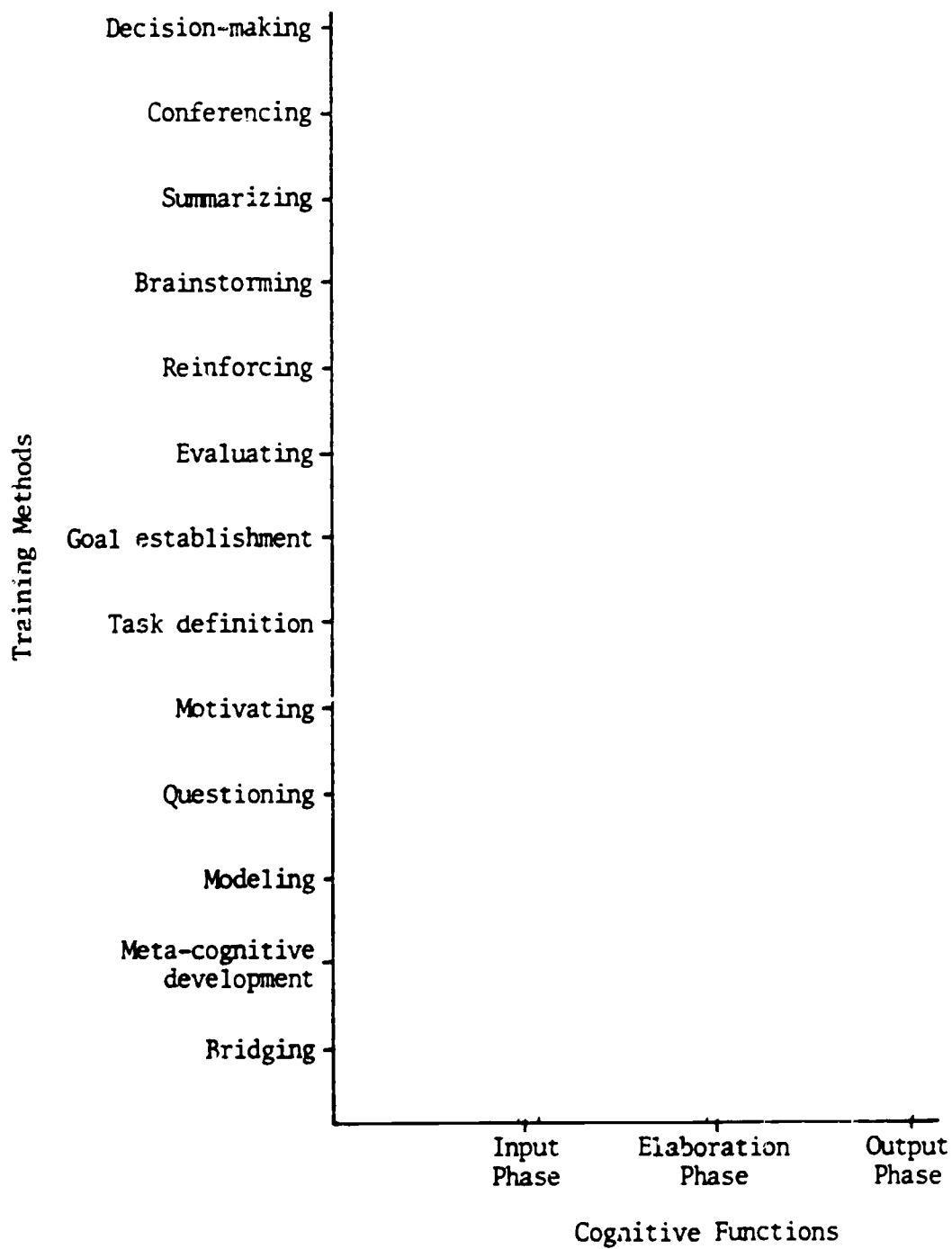
It was further decided to utilize the intervention program, wherever possible, as a means to facilitate further development of all the cognitive functions identified by Feuerstein et al. (1980) as being necessary for efficient thinking and learning.

### 3.9.2 Selection of Training Methodology

- 3.9.2.1 Based on the literature reviewed, it was decided to concentrate on highlighting specific approaches and methods identified by other researchers as being potentially effective in order to assist cooperating teachers with the training of subjects in the use of efficient cognitive functions. The assumption was made that, as experienced teachers were involved in the project, use would be made of other relevant teaching/training methods as need was identified.

- 3.9.2.2 The overall process was modelled after Feuerstein et al.'s (1980) concept of Mediated Learning Experience (MLE). In this framework, the cooperating teachers acted as the mediating agents responsible for mediating, transforming, reordering, organizing, grouping, and framing the stimuli presented in the program activities in the direction of the intended goal of modifying subjects' cognitive functioning. Figure 3.10 provides a graphic representation of these key training methods.

Figure 3.10  
Summary of Training Methods Used for Modifying Cognitive Functions  
in the Intervention Program



- 3.9.2.3 Feuerstein et al.'s (1980) technique of bridging was used extensively to assist students to further develop insight into the principles underlying the cognitive behavior being emphasized in each lesson or activity in the intervention program. This technique was also used to develop subjects' understanding of the cultural implications of cognitive functioning, i.e., the need in certain circumstances to be capable of efficiently utilizing particular cognitive functions. In addition, bridging was used consistently as a means to facilitate development of subjects' understanding of the overall practical utility of efficient cognitive functioning. Other training techniques identified from the literature as being potentially effective included:

- Metacognitive development
- Modeling
- Questioning
- Motivating
- Task definition
- Goal establishment
- Evaluating
- Reinforcing
- Brainstorming
- Summarizing
- Conferencing
- Decision-making

### 3.10 Program Components

The overall intervention program was designed to include five components:

1. Introductory LOGO Computer Language Component;
2. Extended Computer component;
3. Writing Component;
4. Reading Component;
5. Mathematics Component.

Due to its size, 368 pages in total, it is not feasible to reproduce the entire program. A Table of Contents of each component is provided in Appendix C for information. In the following pages, a brief summary of each component is provided.

#### 3.10.1 Introductory LOGO Programming Component

- 3.10.1.1 The Introductory LOGO Programming component of the overall intervention program was developed to introduce the experimental subjects to the LOGO programming language and, through this medium, to develop their awareness of the importance of efficient and effective cognitive functioning. Taught over a period of six weeks immediately prior to the introduction of the

full intervention program, the series of 25 lessons utilized a combination of LOGO programming, Cree beadwork designs, and other geometric designs as a problem-solving environment. Beginning with an introduction to the Apple IIC microcomputer, students were taught a series of increasingly more complex skills and concepts to a level at which they were required to write and test a procedure for creating a design of their own choice.

- 3.10.1.2 The 115-page manual provided to each of the four teachers was organized in the following manner. Each lesson prescribed the LOGO activity to be undertaken by the students. The specific cognitive functions to be addressed in that activity were then specified for the teacher. Suggestions were made to assist with the introduction of the activity and with the encouragement of students' motivation to undertake the activity. Following this, detailed teaching suggestions were provided for each lesson, together with suggestions for bridging activities. Each lesson concluded with a recommended follow-up assignment for students.

3.10.2 Extended Computer Component

- 3.10.2.1 The Extended Computer component was included in the full ten-week intervention program provided to experimental subjects. This component introduced students to word processing utilizing Bank Street Writer and provided a further set of 17 LOGO activities for the students.

- 3.10.2.2 In the word processing section, students were taught how to enter text into the computer, how to edit text, how to save text, and how to obtain a printout. A detailed instructional guide was provided to teachers.

- 3.10.2.3 The additional 17 LOGO computer language lessons were designed to further develop students' abilities in utilizing this medium to facilitate the further development of their cognitive functioning through a problem-solving approach. Lessons 1 through 9 provided activities for three sets of considerations. These were:

1. The facilitation of further development of cognitive functions, with particular attention being given to the functions being highlighted in the overall intervention program;
2. The application of thinking and learning strategies, concepts, and skills being introduced in the academic components of the overall program; and
3. The use of mathematical computations in computer programming.

Lessons 10 through 17 represented an introduction to more complex computer programming by students through a problem-solving approach.

- 3.10.2.4 The 45-page manual provided to teachers contained detailed teaching suggestions for introducing and developing each lesson. In addition, the manual provided suggestions for utilizing the activities to facilitate development of specific cognitive functions and for bridging activities. Student assignment sheets were also provided in the manual.

### 3.10.3 Writing Component

- 3.10.3.1 The Writing Component of the overall intervention program was designed to facilitate the further development of cognitive functions assessed as being generally underdeveloped in the subjects, with particular attention being given to those cognitive functions considered to be of particular importance for the learning of language arts. Training methods identified as being most useful were:

- Bridging;
- Metacognitive development;
- Goal establishment;
- Decision-making;
- Questioning;
- Motivation;
- Modeling;
- Conferencing;
- Problem definition; and
- Task analysis.

- 3.10.3.2 Based on the literature referred to above and on teachers' identification of students' weaknesses, it was decided to stress the following strategy development in the instructional activities:

1. Goal-related planning;
2. Internal constraints in the text;
3. Interconnectedness in the written output;
4. Recursive forward-backward revision processes; and
5. Sub-strategies, including pre-writing activities, drafting, and revising.

- 3.10.3.3 To assist students in developing their cognitive functioning in areas such as planning, overcoming blocking, and avoiding impulsive behavior, recommendations for introducing the writing component were provided in the Instructor's Guide. Teachers were asked to review with their students the overall purpose of

the total intervention program. Following this introduction, it was recommended that the teacher and students should brainstorm reasons why good writing skills are important. These reasons were to apply not only to academic performance, but also to daily life experiences in order to assist with the development of the practical purposes of schooling. It was also suggested that the teacher and students should, together, establish an end objective for the writing program, e.g., a class book of teacher's and students' best writing efforts published for a specific audience such as Band Education Trust Boards, Band Chiefs and Councils, etc.

- 3.10.3.4 In the supporting Extended Computer component, students were introduced to Bank Street Writer. It was explained to students that this could be used for their writing program, that they could continue to use a pencil-and-paper approach, or that they could use a combination of both approaches. Most students preferred to use Bank Street Writer.
- 3.10.3.5 Activities in the actual writing program to be followed over the ten-week period involved a developmental series of five steps. These steps are described below.
- 3.10.3.6 In step one, following the general introduction to the writing program described above, students were each asked to identify six topics they might like to write about, taking into consideration the intended audience. Each student was then asked to select two of those topics for consideration. Finally, each student chose one of these two topics as the first writing activity. Teachers were also asked to go through this process, thereby modeling the strategy for their students.
- 3.10.3.7 In step two, teachers and students were asked to spend an uninterrupted period (about 10 minutes) writing on their chosen topics. Teachers were then asked to circulate and to provide assistance to any students who appeared to be blocking. At the end of this initial writing period, students and teachers were asked to keep their drafts (and all subsequent drafts) in personal folders. It was further recommended that no writing be discarded.
- 3.10.3.8 In step three, on the following day students were to be given half an hour for writing. Teachers, in addition to writing by themselves, were instructed to circulate, to offer encouragement, to comment on points made by students, to stimulate, and to motivate students by questioning. It was suggested that, while some students might wish to continue work on their drafts from the previous day, other students might prefer to work on a different topic from their own list of topics. It was stressed that students should clearly understand the options available to them.

- 3.10.3.9 Teachers were requested to share their own writing with students at the end of this writing period in order to introduce the method of constructive criticism and to develop students' ability to utilize appropriate questions. Teachers were also instructed to model the questioning process involved in constructive criticism, and to encourage discussion of culturally-based implications of this technique.
- 3.10.3.10 In step four, writing continued as in step three. However, teachers were required to introduce the technique of conferencing to being systematic development of strategies for problem-solving. The four types of conferencing were included: Teacher-Large Group Conferencing, Teacher-Individual Student Conferencing, Student-Student Conferencing, and Editing Conferencing.
- 3.10.3.11 Step five, the final step in the process represented the culmination of a particular writing activity. When the writer produced a final draft, it was to be written up and shared with the class as a whole.
- 3.10.3.12 It was recommended to teachers that conventions such as punctuation, capitalization, sentence structure, and spelling be dealt with as part of the editing process when the writer was satisfied with what was written and was ready to produce a final draft. It was also recommended that each teacher note down recurring problems in conventions on an ongoing basis, and that these be dealt with on both an individual and group basis over the ten-week period.
- 3.10.3.13 As students identified the need to acquire further information for their topics, teachers were requested to brainstorm with the students potential sources of relevant information. It was suggested that it might be particularly useful to restrict the content sources to a variety of newspapers in the beginning stages. The reading level in such sources is usually reasonably low and the information is already reasonably well organized. It was recommended that other sources should be introduced later on as the students developed more expertise in selecting and using relevant information. Teachers were asked to encourage students to critically examine the information provided in the sources used, and especially in newspapers since the students represent a sample of the intended audience for the newspaper writers and editors.
- 3.10.3.14 Teachers were requested to encourage students to continually bridge into both person-life situations and other academic learning situations, the principles and strategies being developed in these writing activities. It was directed that each lesson should end with a brief discussion of the

relationship between the strategies and principles being learned and the appropriate cognitive functions being addressed. Teachers were asked to ensure that the students were helped to see the benefits to them of efficient cognitive functioning in both their academic learning and in their everyday life experiences. Furthermore, teachers were asked to assist students to develop the understanding that, while use of the strategies and principles might seem difficult to them, with adult (teachers') help they would be able to learn to use these strategies effectively.

3.10.3.15 The format of the 21-page Instructor' Guide for this Writing Component was as follows:

- |               |   |
|---------------|---|
| Column One:   | Specific cognitive functions being addressed in each activity were identified;  |
| Column Two:   | Specific training methods being used to facilitate the development of these cognitive functions were highlighted; and   |
| Column Three: | Examples of teaching and learning activities were presented. These were designed to assist the students to generalize the targeted cognitive functions to the writing process by identifying and utilizing appropriate learning strategies. This column also included background information for the teacher. |

3.10.4 Reading Component

3.10.4.1 Objectives established for the Reading Component of the overall intervention program included the following:

1. To provide the students with specific strategies which will facilitate the further development of the cognitive functions found to be underdeveloped in the group of participating students, with particular attention being given to those cognitive functions considered to be of particular importance for the learning of language arts;
2. To assist the students to utilize efficient cognitive functioning in their reading activities;
3. To increase the students' own awareness of the importance of efficient and effective cognitive functioning;
4. To upgrade students' abilities in selected areas of reading; and
5. To further develop students' appreciation of reading as a human activity.

To accomplish these objectives, it was considered necessary that the students develop an understanding of the various purposes of reading, of the tasks involved in the reading process, and of the strategies appropriate for efficient and effective reading.

3.10.4.2 The format of the 67-page Instructor's Guide for the Reading Component was as follows:

Pages 1-7	Introduction	Included program objectives, together with supporting theoretical and instructional information;
Pages 8-67	Column One	Identified specific cognitive functions being addressed in each instructional activity;
	Column Two	Highlighted specific training method to be used in the instructional activities to facilitate development of these cognitive functions; and
	Column Three	Described learning strategies to be developed in order to assist students to generalize the cognitive functions to the reading process. Teaching and learning activities were suggested. Sample lessons were presented for each strategy being taught. This column also included, for the teacher, additional background information appropriate to each strategy being addressed.

3.10.4.3 Based on the literature referred to above, the training methods identified as being potentially most useful were:

Bridging;  
Metacognitive development;  
Brainstorming;  
Modeling;  
Goal establishment;  
Motivating;  
Questioning;  
Problem definition;  
Task analysis;  
Evaluating; and  
Reinforcing

3.10.4.4 Based on the literature referred to above, and on the teachers' assessment of specific areas of student weaknesses in reading, it was decided to stress the following strategy development:

- Strategies for:
- 1) brainstorming;
  - 2) vocabulary development;
  - 3) mapping;
  - 4) recognizing and using different signals employed by authors to assist with comprehension of differing types of text structure (included were sequence structure, comparison and contrast structure, and exposition structure); and
  - 5) recognizing structural devices which authors use to signal meaning, i.e., or learning vocabulary from text.

3.10.4.6 Teachers were requested to continually encourage students to bridge use of the strategies being developed in the Reading Component into both person-life situations and other academic learning situations. At the end of each reading activity, teachers were asked to take time to review the particular cognitive functions which students were being encouraged to utilize in that activity. It was stressed that students should be encouraged to identify the relationship between the cognitive functions used in the reading activity and those used in the Extended Computer component. This was considered to be of importance since the LOGO problems stressed the same cognitive functions required for effective academic learning. Finally, teachers were asked to reinforce students' understanding of the fact that, while use of the strategies might seem difficult to them, with adult (teachers') help they would be able to learn to use these strategies effectively.

### 3.10.5 Mathematics Component

3.10.5. Objectives established for the Mathematics Component of the overall intervention program were:

1. To provide students with specific strategies which will facilitate the further development of the cognitive functions found to be underdeveloped in the group of participating students, with particular attention being given to those cognitive functions considered to be of particular importance to the learning of mathematics;
2. To assist the students to utilize efficient cognitive functioning in their mathematics activities;
3. To increase the students' own awareness of the importance of efficient and effective cognitive functioning;

4. To upgrade students' abilities in selected areas of mathematics through the teaching of strategies for learning; and
5. To further develop students' appreciation of mathematics as a human activity.

To accomplish these objectives, it was considered necessary that the students should develop an understanding of the concepts and relationships involved in mathematics, a knowledge of skills and facts, an ability to utilize and apply appropriate strategies, and an appreciation of the attitudes necessary for effective use of mathematics in both school and daily life activities.

3.10.5.2 The format of the 104-page Instructor's Guide for the Mathematics Component was as follows:

Pages 1-7	Introduction	Included program objectives and supporting information, and a description of the overall teaching procedure to be used;
Pages 8-104	Column One	Identified specific cognitive functions being addressed in each instructional activity;
	Column Two	Highlighted specific training methods to be used in the instructional activities to facilitate development of these cognitive functions; and
	Column Three	Detailed teaching and learning activities designed to assist students in generalizing use of these cognitive functions to learning of mathematics by identifying and utilizing appropriate learning strategies. Teaching and learning activities were suggested. Sample lessons were provided for each strategy being taught. Samples of appropriate student worksheets were provided. The column also included additional background information for teachers.

3.10.5.3 The Mathematics Component stressed the further development of those cognitive functions identified by the independent panel of teachers as being of particular importance for the learning of mathematics at the junior high school level. In addition, the

activities provided the opportunity to facilitate further development of other cognitive functions as follows:

- Planning;
- Problem definition;
- Selection of relevant information;
- Clear, complete communication in responding;
- Overcoming impulsive behavior;
- Use of strategies for hypothesis testing; and
- Use of proper labeling.

3.10.5.4 Based on the literature referred to above, the training methods identified as being potentially most useful were:

- Bridging;
- Metacognitive development;
- Motivating;
- Goal establishment;
- Questioning;
- Modeling;
- Decision-making;
- Summarizing; and
- Conferencing.

3.10.5.5 Based on the literature referred to in above, and on the teachers' assessment of specific areas of student weaknesses in mathematics, it was decided to stress the following strategy development:

Strategies for:

- 1) basic computational skills and associated problem-solving;
- 2) ratio, including fractions, and associated problem-solving;
- 3) decimalization and associated problem-solving;
- 4) money, percentages, mark-ups, discount, interest, and associated problem-solving.

3.10.5.6 An overall teaching procedure was identified for use with large groups, with small groups, and with individual students. In summary, this overall teaching procedure involved:

- 1) Initial process--introducing the new activity by using training methods such as questioning, defining terms, discussion of procedures and strategies to be followed, giving instruction, and modeling;

- 2) Ongoing discussion--including procedures and strategies for generating further examples, for systematizing, for classifying, for recording, etc. Discussions should include a review of the procedures being used in the particular activity, possible generalizations, explanations and proof. This discussion should act as a stimulus to activity and should assist with clarification of ideas. It should also provide opportunities to assist students to efficiently utilize the particular cognitive functions being addressed in the activity. The teacher's role should be to move among the students, to stimulate dialogue with the students about their mathematics, to encourage them to talk in greater depth about their work, and to encourage them to ask questions; and
- 3) Concluding discussion--developing the students' awareness of what they had done in the activity and of the significance of both the results obtained and the strategy used. It was stressed that concluding discussion should also provide opportunity to continually assess the students' conceptual and skill development and, from there, to determine the nature of additional assistance required. Students were to be encouraged to verbalize the strategies used in the activity. These verbalizations were to be recorded on charts and placed in a prominent location in the classroom. The final discussion concluded with a review of the particular cognitive functions being addressed in the activity, and with a discussion of the importance of efficient and effective use of these functions in the learning of mathematics.

With this overall framework, the Instructor's Guide provided specific instructional activities to:

1. Introduce the Mathematics Component to students;
2. Assist students requiring remedial measures in basic computational facts and concepts;
3. Teach the strategies outlined above;
4. Practice use of these strategies;
5. Assess students' abilities to use these strategies efficiently;
6. Use appropriate terminology; and
7. Apply strategies learned to problem-solving activities.

- 3.10.5.7 Teachers were requested to continually encourage students to bridge use of the strategies learned in the Mathematics Component into both personal-life situations and other academic learning situations. At the end of each mathematical activity, teachers were asked to take time to review the particular cognitive functions used in that activity. In addition, it was stressed that students should be encouraged to identify the relationship between the cognitive functions used in the mathematics activities and those used in each of the other components of the overall intervention program. Finally, teachers were asked to reinforce students' understanding of the fact that, while use of some of the strategies might seem difficult to them, with adult (teachers') help, they will be able to learn to use these strategies effectively.

3.11 In-Service for Cooperating Teachers

- 3.11.1 Teachers of experimental subjects were provided with a total of four days of in-service together with regular ongoing support throughout the study.
- 3.11.2 The first in-service session, of one-day duration, was held in early December, 1984. This session, conducted by an expert in the LOGO programming from the University of Calgary, introduced the teachers to the use of the Apple IIC microcomputer and to LOGO. Following this training, teachers practiced use of LOGO on their own time in preparation for a second in-service session.
- 3.11.3 The second one-day in-service session for teachers of experimental subjects was held at the beginning of January, 1985. During this session the program for the first two weeks of the Introductory course was presented to teachers, and training was provided on methods of teaching these lessons. In addition, teachers were provided with training on methods for using the lessons to facilitate the development of thinking skills by the students. Thereafter, each cooperating teacher was visited every two weeks to provide ongoing assistance and advice to the cooperating teachers as required.
- 3.11.4 The third in-service session for the cooperating teachers represented a two-day workshop conducted in late February. The primary objectives for this workshop were:
1. To review the overall purpose of the project;
  2. To review, on a group basis, the results from the initial cognitive assessments, with particular attention to the underdeveloped cognitive functioning underlying the patterns of errors made by subjects;

3. To provide in-service in methods of utilizing LOGO to facilitate development of cognitive functions;
4. To provide in-service in methods of teaching for the development of strategies identified in the academic program components;
5. To provide in-service in using the combination of LOGO and the three academic program components to facilitate the further development of cognitive functions; and
6. To obtain advice on the nature of ongoing support which should be provided during the full implementation phase.

3.11.5 During the full implementation phase, ongoing support was provided to the four cooperating teachers through weekly visits to each group. During these visits, the activities included in the Instructor's Guides were discussed and additional suggestions made as required. When ever possible, brief discussions were held with subjects in each group in order to assist the teachers with maintaining subjects' motivation through expression of interest in their learning activities.

### 3.12 Involvement of Teachers of Control Subjects

3.12.1 In order to encourage a feeling of involvement in the project, offers to discuss the project with teachers of control subjects were made to both participating schools. In both cases, the schools' administrators preferred to undertake this responsibility themselves in order to facilitate their own program of staff in-service. The research team was assured that staff involved with control subjects were aware of the process being undertaken and understood the purposes of the project. Regular discussions were held with both administrations in the control schools during the ten weeks of full implementation of the intervention program in order to ensure that all pertinent information concerning the project was available to them. A commitment was made to meet with their staffs upon completion of the project and analysis of results.

### 3.13 Assessment of Manifest Level of Cognitive Functioning of Control and Experimental Subjects

3.13.1 At the conclusion of the Introductory LOGO Programming Component, all students (control and experimental) were group administered the following tests:

1. Learning Potential Assessment Device (L.P.A.D.), Variations I;
2. Learning Potential Assessment Device (L.P.A.D.), Variations II;

3. Representational Stencil Design Test (R.S.D.T.),  
Parallel Form.

These tests were group administered by F. Carnew, using procedures dictated by the test constructors. Subjects were provided with sufficient information to ensure that they understood the tasks to be completed in each test. Tests were administered in the order indicated above.

- 3.13.2 Prior to the actual testing, a review of the overall purposes of the project was orally presented to each group. In addition, subjects were advised that the results of the cognitive assessments would be interpreted to them on an individual basis at a later date.

3.14 Assessment of Attitudes Towards Mathematics  
and Language Arts: All Subjects

- 3.14.1 Following the assessments of manifest level of cognitive , functioning each group (control and experimental) was administered the Schools Subjects Attitudes Scales. Tests were administered according to the procedures established by the test constructors (see Description of Tests above). Again, the purpose of this assessment was explained to all subjects.

3.15 Assessment of Manifest Level of Academic Functioning  
in Mathematics and Language Arts: All Subjects

- 3.15.1 The Canadian Tests of Basic Skills, Multilevel Edition/Levels 9-14, Form 5, Mathematics and Language Arts were group administered to all subjects (control and experimental). All tests were administered according to the procedures described earlier (see Test Description: Academic Tests above). All tests were scored by this writer.

3.16 Interpreting and Reporting of Cognitive  
Assessment Results to All Subjects

- 3.16.1 Shortly after completion of this testing process, each group (control and experimental) was visited for the purpose of providing feedback of results to each subject on an individual basis. The primary purposes of this exercise were to assist with each individual's metacognitive development and to assist with sustaining each subject's motivation.
- 3.16.2 Prior to the presentation of results, the purposes of the overall program, including assessments, were reviewed with each subject. With control subjects, particular attention was given to reviewing their role in the study. The requirements of

scientific research was briefly discussed, and the importance of control subjects in this research was briefly addressed. It was explained to each control subject that the final report from the research, together with a copy of the program materials, would be made available to each participating school. In addition, each control subject was advised that, if future program recommendations based on the overall assessments could be formulated, these would be discussed with the subject at the end of the project and, with the subject's approval, made available to their respective school principals.

- 3.16.3 Following the introductory comments, the assessment results were presented to each student. Particular attention was given to providing positive comment on each subject's performance. Patterns of errors were discussed from the perspective of cognitive functioning. In the case of experimental subjects, these errors were directly related to the list of cognitive functions addressed in the Introductory LOGO Programming Component. With control subjects, these errors were discussed in more general terms with effort made to increase each subject's understanding of the cognitive functioning involved in the particular task. The importance of efficient cognitive functioning in both academic learning and general life situations was briefly discussed with each control subject. In addition, some general suggestions relating to means by which cognitive functioning may be improved were briefly presented. Each session with both control and experimental subjects concluded with a brief overview of the remaining steps to be undertaken in the study.

3.17 Implementation of Full Intervention Program

- 3.17.1 The full intervention program, i.e., the Extended Computer Component, the Writing Component, the Reading Component, and the Mathematics Component, was provided to experimental subjects during a ten-week period. This ten-week period lasted from March 11, 1985 through May 17, 1985.

3.18 Final Assessments of Control and Experimental Subjects:  
Cognition, Academic, and Attitudes

- 3.18.1 During the two weeks following the completion of the intervention program, the following tests were group administered to both control and experimental subjects in the order indicated below:
1. Learning Potential Assessment Device (L.P.A.D.),  
Variations I;
  2. Learning Potential Assessment Device (L.P.A.D.),  
Variations II;

3. Representational Stencil Design Test (R.S.D T.), Parallel Form;
4. Schools Subjects Attitudes Scales (Mathematics and Language Arts); and
5. Canadian Tests of Basic Skills, Multilevel Edition/ Levels 9-14, Form 6, Mathematics and Language Arts.

All tests were administered according to the procedures described earlier.

3.19                      Final Interviews with Teachers  
   of Experimental Groups

- 3.19.1      A debriefing session was held separately with each of the four cooperating teachers of experimental subjects following the termination of the program. In addition, a session was held with all four teachers in order to provide opportunity to discuss the program and to provide anecdotal comments. The outcome of these sessions is discussed below.

3.20                      Final Interviews with School Administrations:  
   Control Groups

- 3.20.1      A debriefing session was conducted with each of the administrators from schools involved with the two control groups. The outcome of these sessions is discussed below.

3.21                      Final Reporting of Assessment Results to Subjects

- 3.21.1      Each group, control and experimental, was visited in early June in order to provide feedback to each student. These sessions followed the same basic pattern reported earlier. Changes in performances on the cognitive and academic tests were identified, as were changes in responses on the Schools Subjects Attitudes Scales. Recommendations for further programs were discussed with subjects, and permission was requested to discuss these recommendations with their respective teachers or principals. Each session ended with a brief review of the purpose of the study, of the importance of each subject's participation in the study, and with an expression of gratitude for their involvement.

3.22                      Experimental Design

- 3.22.1      A three factor 2x2x2 experimental design with one repeated measure was used for this study. This design matrix is illustrated in Figure 3.11.

Figure 3.11  
The Design Matrix

		TIME					
		Pretest			Posttest		
GROUP	SEX	Cognition	Attitude	Academic	Cognition	Attitude	Academic
Control	Male						
	Female						
Experimental	Male						
	Female						

3.23

Treatment of the Data

- 3.23.1 Main analyses of the data were conducted utilizing the BMDP 4V statistical software package for multivariate analysis of variance. The BMDP 4V package was selected because of the flexibility and comprehensiveness of its MANOVA program, for the ability of the package to handle more than one dependent measure in the multivariate repeated measures analysis, and for the program's usage of "a cell-weighting system to specify hypotheses to be tested, particularly with respect to adjustment for unequal n" (Tabachnick & Fidell, 1983, pp.263-264)

A statistical level of .05 two-tailed was selected for significance in testing all hypotheses.

#### 4.0 ANALYSIS OF TEST RESULTS

4.1 Variables considered in this study included the manner in which a cognitive education intervention program might affect under-achieving Native adolescent cognitive development, in addition towards and interest in academic subjects. As discussed above, the study adopted a series of tests as dependent measures and the analysis of these will now be reported. In addition to the use of test scores, an effort was also made to gather anecdotal data during the project. Anecdotal data will be reported below.

#### 4.2 Computer Awareness Questionnaire

4.2.1 The purpose of this questionnaire was to determine subjects' familiarity with computers and typewriters prior to participation in the intervention program. This measure was used as a control for the possibility that prior experience with the technology might result in differential performance by control or experimental groups. Analysis of the questionnaire results indicated no difference between the two groups of students in terms of such experience.

#### 4.3 Introductory LOGO Programming Component

4.3.1 Prior to the introductory LOGO programming component the Raven's CPM, Raven's SPM, and the Representational Stencil Design Test (RSDT) were given to subjects in both experimental and control groups. At the conclusion of this introductory component the Learning Assessment Potential Device--Variation 1 (LPAD1), the Learning Assessment Potential Device--Variation 1 (LPAD2), and the Representational Stencil Design Test (Alternate Form) were given. Feuerstein (1980) claims that the LPAD1 questions are all variations of a subset of the Raven's CPM items B8-B12, and that all LPAD2 questions are variations of the Raven's SPM items C7, C8, C12, D12 and E12. His method of comparing percentage correct scores on the LPAD tests with scores on the comparable items of the Raven's tests was adopted. Two (Treatment) x 2 (Time) mixed multivariate analyses of variance were performed on the three sets of dependent measures with Treatment (experimental vs control) as a between-subjects variable and Time (Pretest vs Posttest) as a within-subjects variable.

4.3.2 Both pre- and posttest scores were available for 45 of the 69 subjects originally tested. This sample size of 45 was reduced to 44 with the deletion of one within-cell outlier with a score on LPAD1 more than three standard deviations below the mean score on that measure. The 2 x 2 mixed multivariate analysis of variance outlined above revealed a significant effect of Time on the combined dependent variables. No significant effects due to Treatment ( $F(3,40) = 1.8, p > .05$ ) or the interaction of Treatment with Time ( $F(3,40) = 2.75, p > .05$ ) were found.

Table 1  
Descriptive Statistics from Performances  
on Pretests Assessing Levels of Cognitive Development:  
All Subjects

Group	Test	N	Mean	Standard Deviation
Control	LPAD I	18	21.39	5.63
	LPAD II	18	28.44	9.34
	RSDT II	18	28.17	14.94
Experimental	LPAD I	38	19.68	5.23
	LPAD II	38	25.45	7.88
	RSDT II	38	32.55	11.20

Table 2  
Descriptive Statistics from Performances  
on Pretests Assessing Levels of Cognitive Development:  
All Subjects

Group	Test	N	Mean	Standard Deviation
Control	LPAD I	18	23.39	4.94
	LPAD II	18	33.78	10.96
	RSDT II	18	36.67	14.24
Experimental	LPAD I	38	25.50	2.96
	LPAD II	38	36.34	8.29
	RSDT II	38	41.03	10.14

Key:

LPAD I: Learning Potential Assessment Device, Variations I  
LPAD II: Learning Potential Assessment Device, Variations II  
RSDT II: Representational Stencil Design Test, Parallel Form

- 4.3.3 While there is anecdotal evidence (discussed below) that indicates positive change in subjects associated with this introductory component, the absence of any Treatment with Time interaction would suggest the absence of the hoped-for cognitive modification as a result of the introductory component. (An alternate explanation, of course, would be that the Raven's and LPAD tests are not equivalent and hence comparison of the scores was inappropriate.)

For the remainder of this report, test scores obtained at the conclusion of the introductory LOGO Programming component will be used as the benchmark and comparisons made between them and tests administered at the conclusion of the project. Hence, for the remainder of the report "pretest" will refer to the tests administered between the introductory component and the full intervention program.

4.4 Total Project - Hypothesis 1

There would be a significant difference between the manifest level of cognitive functioning as assessed by subjects' performances on pretests and the level of cognitive functioning as assessed by subjects' performances on posttests.

- 4.4.1 A multivariate analysis of variance with one repeated measure was conducted to determine the significance of the differences between scores obtained by each of the two groups, control and experimental, on each of the three instruments used to test this hypothesis. This analysis included all those subjects who completed these three instruments over both assessments, but who did not necessarily complete all other instruments used in the study. Descriptive statistics from performances on each of the three instruments used to test this hypothesis are reported in Tables 1 and 2.
- 4.4.2 Results from the multivariate analysis of variance with one repeated measure of cognitive development are reported for the Learning Potential Assessment Device (Variations I), the Learning Potential Assessment Device (Variations II), and the Representational Stencil Design Test (Parallel Forms) in Tables 3, 4 and 5 respectively. An interaction effect for Group by Time was found to be significant ( $p < .05$ ) for both variations of the Learning Assessment Potential Device (see figures 4.1 and 4.2), though no such interaction was found for the Representational Stencil Design Test. A significant main effect for Time ( $p < .05$ ) was found for the Representational Stencil Design Test--however, one cannot assume that the intervention was necessarily a contributing factor to this change.

Table 3

## Multivariate Analysis of Variance with Repeated Measures

of Cognitive Development as Assessed by the Learning Potential Assessment Device (LPAD),

Variations I: All Subjects

Source of Variation	SS	MSS	DF	F	P
<b>Main Effects</b>					
Group (G)	2.30	2.30	1, 52	0.07	0.792
Sex (S)	36.81	36.81	1, 52	1.13	0.293
Time (T)	371.52	371.52	1, 52	89	0.001
<b>Interaction</b>					
G × S	0.486	0.486	1, 52	0.01	0.903
G × T	79.994	79.994	1, 52	7.73	0.008
T × S	35.255	35.255	1, 52	3.41	0.071
T × S × G	2.280	2.280	1, 52	0.22	0.641
<b>Error</b>					
G × S	1698.025	32.654			
T × S × G	538.231	10.351			

Key: Group = Control vs Experimental  
Sex = Male vs Female  
Time = Pretests vs Posttests

Table 4

Multivariate Analysis of Variance with Repeated Measures  
of Cognitive Development as Assessed by the Learning Potential Assessment Device (LPAD),  
Variations II: All Subjects

Sources of Variation	SS	MSS	DF	F	P
<b>Main Effects</b>					
Group (G)	0.413	0.413	1, 52	0.00	0.954
Sex (S)	39.001	39.001	1, 52	0.32	0.576
Time (T)	1559.680	1559.680	1, 52	45.76	0.001
<b>Interaction</b>					
G × S	9.286	9.286	1, 52	0.08	0.785
G × T	180.079	180.079	1, 52	5.28	0.027
T × S	33.256	33.256	1, 52	0.98	0.330
T × S × G	52.456	52.456	1, 52	1.54	0.220
<b>Error</b>					
G × S	6388.356	122.853			
T × S × G	1772.500	34.086			

Key: Group = Control vs Experimental  
Sex = Male vs Female  
Time = Pretests vs Posttests

Table 5

**Multivariate Analysis of Variance with Repeated Measures  
of Cognitive Development as Assessed by the Representational Stencil Design Test (RSDT),  
Parallel Form: All Subjects**

Source of Variation	SS	MSS	DF	F	P
<b>Main Effects</b>					
Group (G)	550.210	550.210	1, 52	2.07	0.156
Sex (S)	483.151	483.151	1, 52	1.82	0.183
Time (T)	1724.650	1724.650	1, 52	64.98	0.001
<b>Interaction</b>					
G x S	24.539	24.539	1, 52	0.09	0.762
G x T	0.168	0.168	1, 52	0.00	0.994
T x S	0.607	0.607	1, 52	0.02	0.880
T x S x G	8.956	8.956	1, 52	0.34	0.564
<b>Error</b>					
G x S	13804.456	265.470			
T x S x G	1380.050	26.539			

Key: Group = Control vs Experimental  
Sex = Male vs Female  
Time = Pretests vs Posttests

Figure 4.1  
Graphical Representation of the Interaction Effect  
of Time  $\times$  Group on Cognitive Development as Assessed  
by the Learning Potential Assessment Device (LPAD), Variations I:  
All Subjects

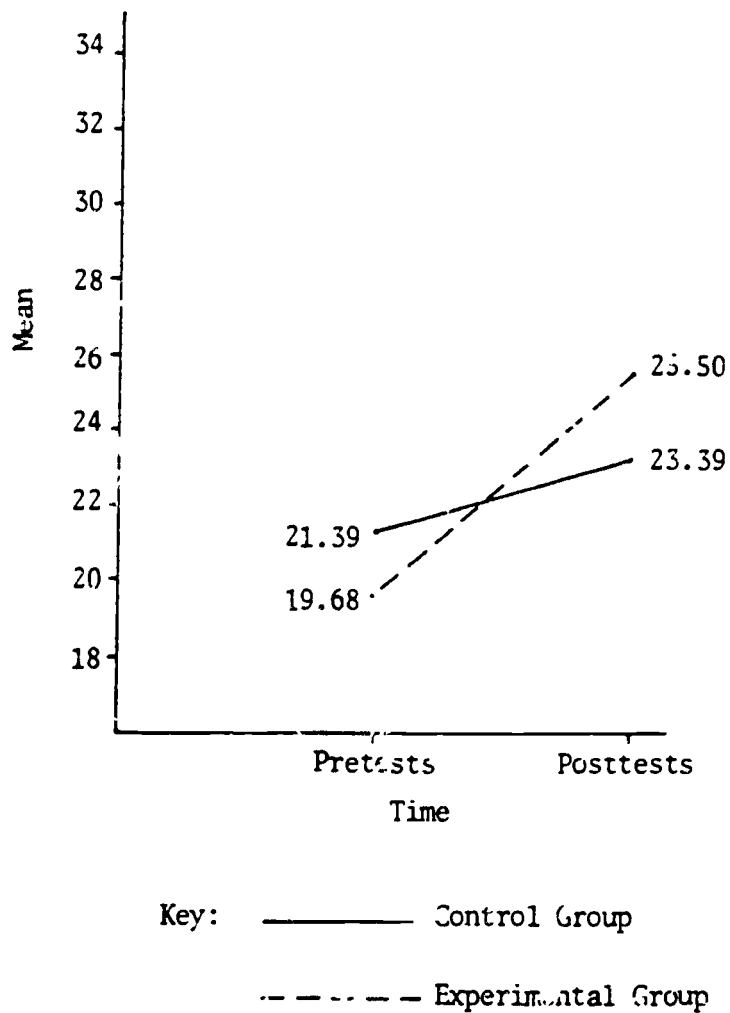
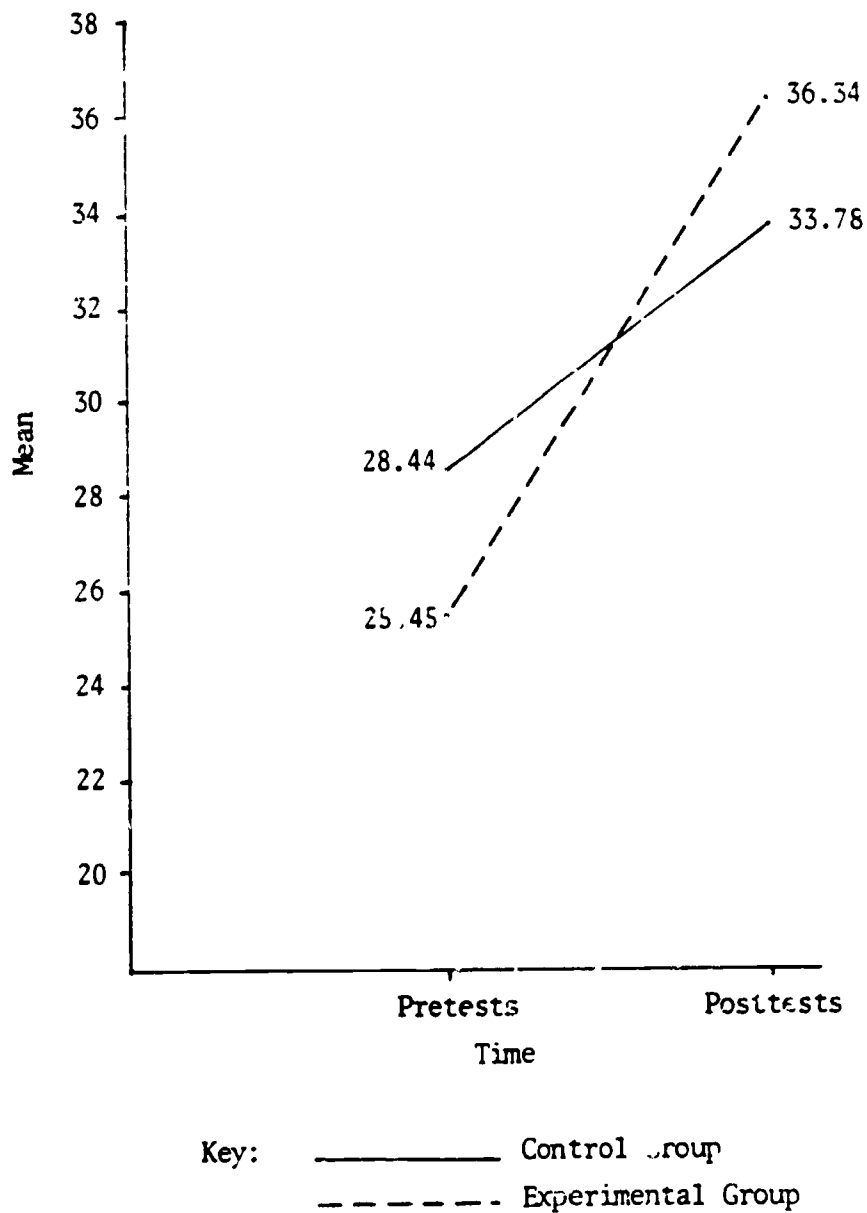


Figure 4.2  
Graphical Representation of the Interaction Effect  
of Time  $\times$  Group on Cognitive Development as Assessed  
by the Learning Potential Assessment Device (LPAD), Variations II:  
All Subjects



- 4.4.3 Based on the foregoing, there was judged to be sufficient evidence to support the first hypothesis that there would be a significant difference in cognitive functioning between pretesting, and posttesting in favour of the experimental group.

4.5 Total Project - Hypothesis 2

**There would be a significant difference between subject's attitudes towards mathematics and language arts as assessed by responses on pretests and or posttests.**

- 4.5.1 To test this hypothesis, a multivariate analysis of variance with one repeated measure was conducted to determine the significance of the differences between responses obtained by each of the two groups on each of the three scales from the School Subjects Attitude Scales (Nyberg & Clarke, 1983). These three scales were (a) an evaluative scale, (b) a usefulness scale, and (c) a difficulty scale. Results are reported first for mathematics and then for language arts (reading and writing).

4.5.2 Mathematics

Descriptive statistics for responses on each of the three scales used to assess attitude toward mathematics are reported in Table 6 (pretest) and Table 7 (posttest). Results from multivariate analysis of variance with one repeated measure of attitude towards mathematics as indicated by responses on the evaluation, usefulness and difficulty scales are presented in Tables 8, 9 and 10 respectively. In no instance were any F-values found to be statistically significant and it was concluded that no change had taken place in subject's attitudes toward mathematics.

4.5.3 Language Arts

Descriptive statistics for responses on each of the three scales used to assess attitude toward language arts (reading and writing) are reported in Table 11 (pretest) and Table 12 (posttest). Tables 13, 14 and 15 report the results of multivariate analysis of variance with one repeated measure for each of the three scales. In each case the F-value for the interaction of Group by Time was statistically significant ( $p < .05$ ). The direction of the difference in each case was the direction predicted (see Figures 4.3, 4.4, and 4.5); i.e., the experimental group perceived language arts to be more useful and less difficult at the end of the treatment.

Table 6  
Descriptive Statistics from Responses  
on Pretests Assessing Attitudes Towards Mathematics:  
All Subjects

Group	Scales	N	Mean	Standard Deviation
Control	Evaluation	18	26.89	3.39
	Usefulness	18	33.61	4.50
	Difficulty	18	25.17	5.03
Experimental	Evaluation	29	26.79	7.59
	Usefulness	29	32.14	6.50
	Difficulty	29	24.76	5.63

Table 7  
Descriptive Statistics from Responses  
on Posttests Assessing Attitudes Towards Mathematics:  
All Subjects

Group	Scales	N	Mean	Standard Deviation
Control	Evaluation	18	26.61	9.52
	Usefulness	18	33.94	5.54
	Difficulty	18	26.56	5.41
Experimental	Evaluation	29	27.24	8.40
	Usefulness	29	33.03	7.65
	Difficulty	29	23.48	4.54

Table 8  
Multivariate Analysis of Variance with Repeated Measures  
of Attitude Towards Mathematics, Evaluation Scale:  
All Subjects

Source of Variation	SS	MSS	DF	F	P
<b>Main Effects</b>					
Group (G)	39.907	39.907	1, 43	0.32	0.575
Sex (S)	51.520	51.520	1, 43	0.41	0.524
Time (T)	22.270	22.270	1, 43	1.13	0.294
<b>Interaction</b>					
G x S	16.075	16.075	1, 43	0.13	0.721
G x T	47.586	47.586	1, 43	2.41	0.128
T x S	27.620	27.620	1, 43	1.40	0.244
T x S x G	9.463	9.463	1, 43	0.48	0.493
<b>Error</b>					
G x S	5361.4167	124.684			
T x S x G	849.264	19.750			

Key: Group = Control vs Experimental  
Sex = Male vs Female  
Time = Pretests vs Posttests

Table 9  
Multivariate Analysis of Variance with Repeated Measures  
of Attitude Towards Mathematics, Usefulness Scale:  
All Subjects

Source of Variation	SS	MSS	DF	F	P
<b>Main Effects</b>					
Group (G)	39.907	39.907	1, 43	0.32	0.575
Sex (S)	68.929	68.929	1, 43	1.09	0.310
Time (T)	7.736	7.736	1, 43	0.44	0.512
<b>Interaction</b>					
G × S	5.103	5.103	1, 43	0.08	0.778
G × T	0.926	0.926	1, 43	0.05	0.820
T × S	62.058	62.058	1, 43	3.51	0.068
T × S × G	31.241	31.241	1, 43	1.77	0.191
<b>Error</b>					
G × S	2714.238	63.122			
T × S × G	760.018	17.675			

Key: Group = Control vs Experimental  
Sex = Male vs Female  
Time = Pretests vs Posttests

Table 10

Multivariate Analysis of Variance with Repeated Measures  
of Attitude Towards Mathematics, Difficulty Scale:  
All Subjects

Source of Variation	SS	MSS	DF	F	P
<b>Main Effects</b>					
Group (G)	50.921	50.921	1, 43	1.28	0.264
Sex (S)	103.091	103.091	1, 43	2.60	0.114
Time (T)	0.312	0.312	1, 43	0.00	0.999
<b>Interaction</b>					
G $\times$ S	59.036	59.036	1, 43	1.49	0.230
G $\times$ T	37.304	37.304	1, 43	2.97	0.092
T $\times$ S	0.528	0.528	1, 43	0.00	0.984
T $\times$ S $\times$ G	13.561	13.561	1, 43	1.08	0.305
<b>Error</b>					
G $\times$ S	1706.095	39.677			
T $\times$ S $\times$ G	540.781	12.576			

Key: Group = Control vs Experimental  
Sex = Male vs Female  
Time = Pretests vs Posttests

Table 11

Descriptive Statistics from Responses on Pretests  
Assessing Attitudes Towards Language Arts (Reading and Writing):  
All Subjects

Group	Scale	N	Mean	Standard Deviation
Control	Evaluation	18	30.61	8.94
	Usefulness	18	35.39	4.45
	Difficulty	18	23.22	6.43
Experimental	Evaluation	28	28.86	7.15
	Usefulness	28	30.46	7.05
	Difficulty	28	23.86	4.76

Table 12

Descriptive Statistics from Responses on Posttests  
Assessing Attitudes Towards Language Arts (Reading and Writing):  
All Subjects

Group	Scale	N	Mean	Standard Deviation
Control	Evaluation	18	25.50	10.19
	Usefulness	18	32.67	7.15
	Difficulty	18	24.39	6.63
Experimental	Evaluation	28	28.11	7.91
	Usefulness	28	33.82	6.66
	Difficulty	28	21.50	4.22

Table 13

Multivariate Analysis of Variance with Repeated Measures  
of Attitude Towards Language Arts (Reading and Writing), Evaluation Scale:  
All Subjects

Source of Variation	SS	MSS	DF	F	P
<b>Main Effects</b>					
Group (G)	4.760	4.760	1, 42	0.04	0.838
Sex (S)	261.537	261.537	1, 42	2.33	0.134
Time (T)	79.545	79.545	1, 42	3.03	0.090
<b>Interaction</b>					
G × S	53.459	53.459	1, 42	0.48	0.494
G × T	217.506	217.506	1, 42	8.30	0.006
T × S	0.117	0.117	1, 42	0.00	0.947
T × S × G	1.379	1.379	1, 42	0.05	0.820
<b>Error</b>					
G × S	4705.4	112.030			
T × S × G	1101.129	26.217			

**Key:** Group = Control vs Experimental  
Sex = Male vs Female  
Time = Pretests vs Posttests

**Table 14**  
**Multivariate Analysis of Variance with Repeated Measures**  
**of Attitude Towards Language Arts (Reading and Writing), Usefulness Scale:**  
**All Subjects**

Source of Variation	SS	MSS	DF	F	P
<b>Main Effects</b>					
Group (G)	70.532	70.532	1, 42	1.17	0.285
Sex (S)	107.232	107.232	1, 42	1.78	0.189
Time (T)	4.112	4.111	1, 42	0.17	0.682
<b>Interaction</b>					
G × S	10.902	10.902	1, 42	0.18	0.673
G × T	185.723	185.723	1, 42	7.71	0.008
T × S	3.717	3.717	1, 42	0.15	0.697
T × S × G	62.785	62.785	1, 42	2.61	0.114
<b>Error</b>					
G × S	2529.923	60.236			
T × S × G	1012.209	24.100			

**Key:** Group = Control vs Experimental  
Sex = Male vs Female  
Time = Pretests vs Posttests

Table 15

Multivariate Analysis of Variance with Repeated Measures  
of Attitude Towards Language Arts (Reading and Writing), Difficulty Scale:  
All Subjects

Source of Variation	SS	MSS	DF	F	P
<b>Main Effects</b>					
Group (G)	20.259	20.259	1, 42	0.44	0.510
Sex (S)	14.388	14.388	1, 42	0.31	0.578
Time (T)	7.438	7.438	1, 42	0.61	0.440
<b>Interaction</b>					
G x S	95.825	95.825	1, 42	2.09	0.156
G x T	68.319	68.319	1, 42	5.58	0.023
T x S	2.064	2.064	1, 42	0.17	0.684
T x S x G	0.316	0.316	1, 42	0.03	0.873
<b>Error</b>					
G x S	1925.810	45.852			
T x S x G	514.580	12.252			

**Key:** Group = Control vs Experimental  
Sex = Male vs Female  
Time = Pretests vs Posttests

Figure 4.3

Graphical Representation of the Interaction Effect  
of Time  $\times$  Group on Attitude Towards Language Arts (Reading and  
Writing) as Assessed by the Evaluation Scale All Subjects

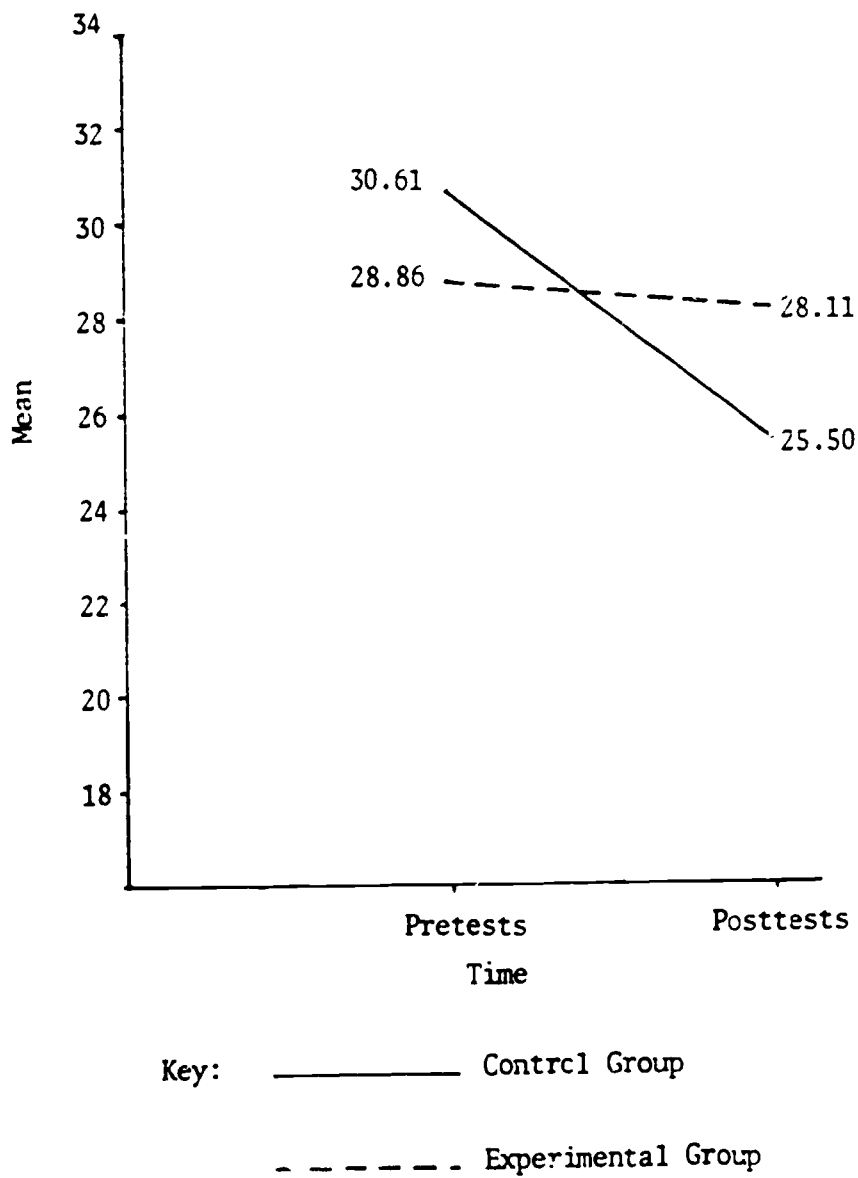


Figure 4.4

Graphical Representation of the Interaction Effect  
of Time  $\times$  Group on Attitude Towards Language Arts (Reading and  
Writing) as Assessed by the Usefulness Scale: All Subjects

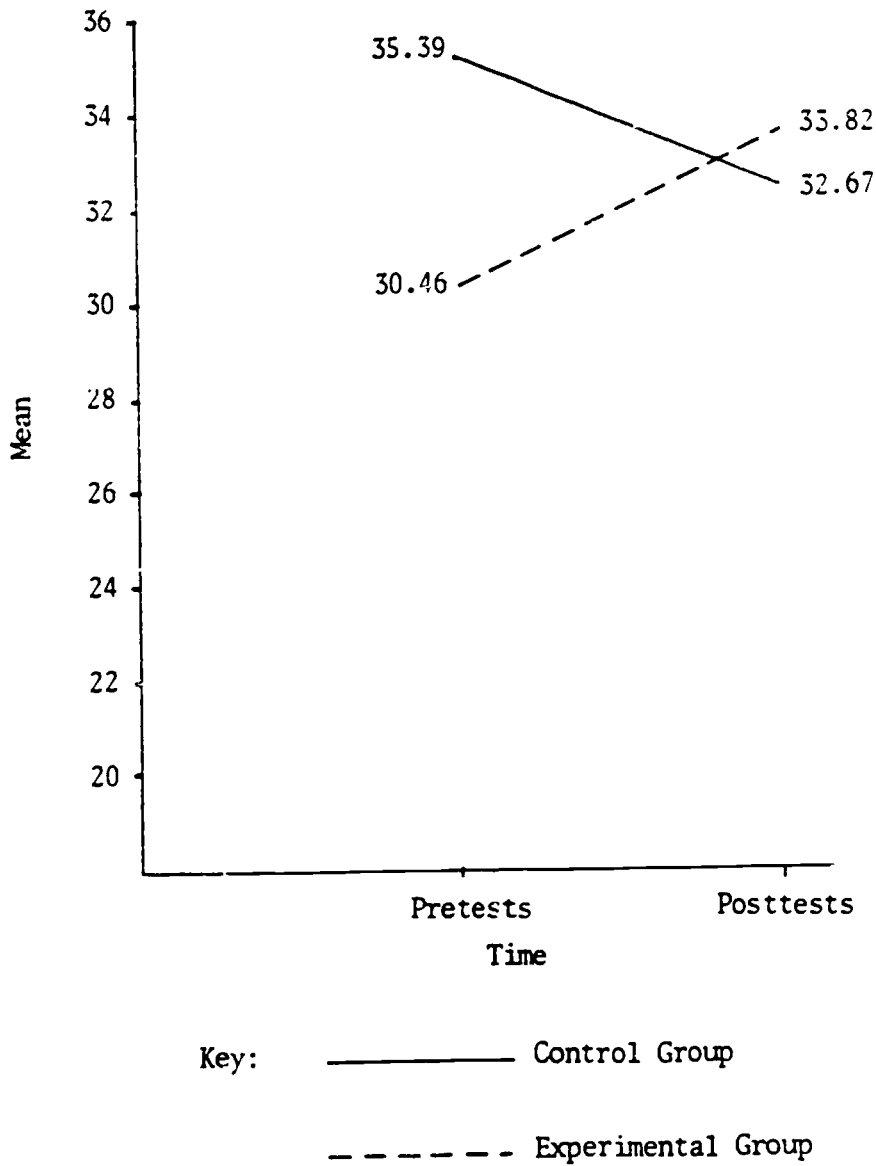
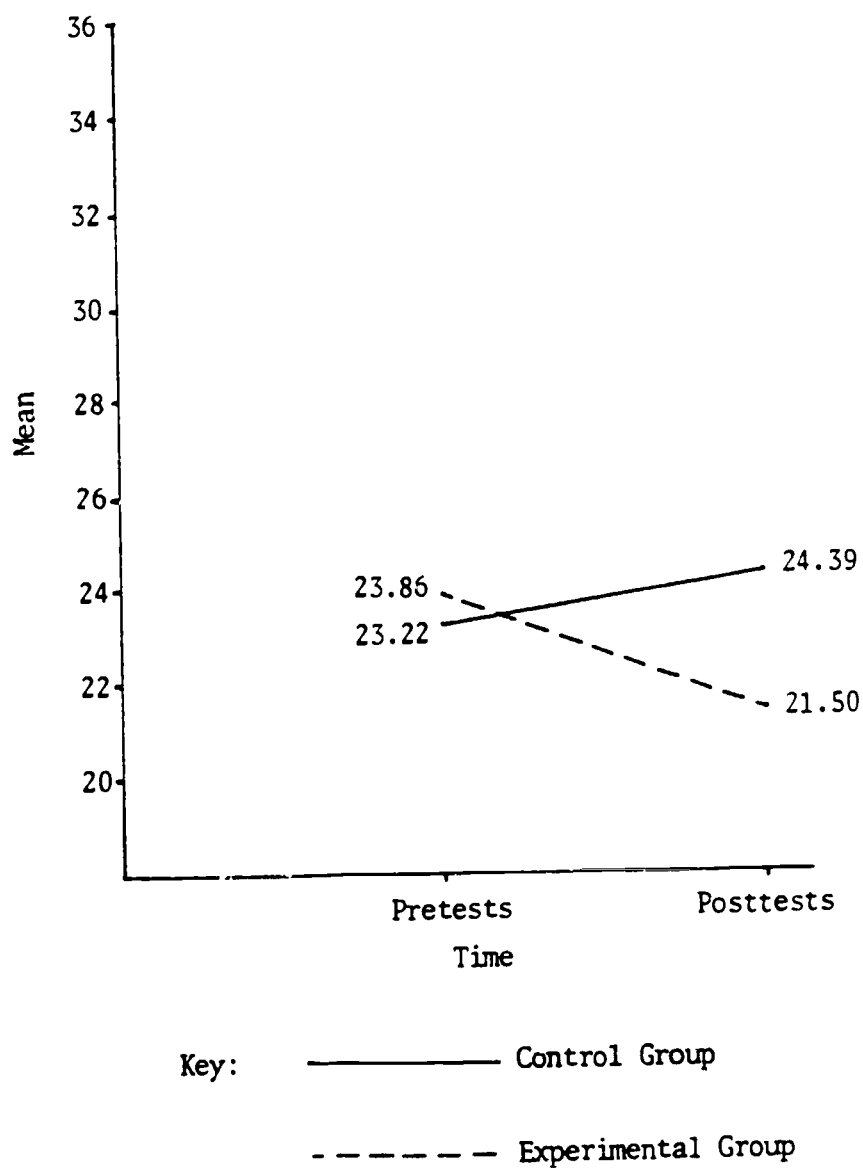


Figure 4.5  
Graphical Representation of the Interaction Effect  
of Group  $\times$  Time on Attitude Towards Language Arts (Reading and  
Writing), Difficulty Scale: All Subjects



- 4.5.4 Based on this analysis, it was concluded that sufficient evidence existed to support Hypothesis 2 that there would be a change in attitude with respect to language Arts; however, it was not supported with respect to Mathematics.

4.6 Total Project--Hypothesis 3

**There would be a significant difference between the level of academic functioning in mathematics, reading, and writing as assessed by subjects' performances on pretests and posttest.**

- 4.6.1 In order to determine if significant differences in performance were obtained by each of the two groups, control and experimental, on each of the three academic subject areas used to test this hypothesis, a multivariate analysis of variance with one repeated measure was conducted. Descriptive statistics for performances on each of the pretests assessing manifest levels of academic functioning in mathematics, reading, and writing are reported in Table 16. Table 17 contains descriptive statistics from subjects' performances on the posttests administered following the intervention program. Differences in means may be readily observed from these tables. Results of analyses are reported first for mathematics, then for reading, and finally for writing.

4.6.2 Mathematics

Table 18 reports results of the multivariate analysis of variance with one repeated measure used to assess significance of differences in performance between the control and experimental groups in mathematics. No F-values were found to be statistically significant for any interaction effects. However, the main effects of group and of time were statistically significant (p.05). This is interpreted as indicating (a) that a significant difference did exist between the groups at pretest and (b) that within each group a significant difference existed in performance between pretest and posttest, as is graphically represented in Figure 4.6. This is insufficient to conclude whether the experimental intervention can be credited with a greater increase in performance in mathematics than would otherwise have occurred without it. One can speculate that greater effort is required to move the mean from 42.34 to 48.81 than from 58.72 to 68.94, but it is only speculation.

4.6.3 Reading

To determine if there was a significant statistical difference between scores obtained by the control and experimental groups in reading, a multivariate analysis of variance with one

Table 16  
Descriptive Statistics from Performances  
on Pretests Assessing Level of Academic Functioning:  
All Subjects

Group	Academic Subject	N	Mean	Standard Deviation
Control	Mathematics	18	58.72	23.30
	Reading	18	58.28	17.51
	Writing	18	76.44	21.49
Experimental	Mathematics	32	42.34	24.46
	Reading	38	41.08	21.59
	Writing	35	50.83	28.51

Table 17  
Descriptive Statistics from Performances  
on Posttests Assessing Level of Academic Functioning:  
All Subjects

Group	Academic Subject	N	Mean	Standard Deviation
Control	Mathematics	18	68.94	20.66
	Reading	18	61.72	16.81
	Writing	18	78.78	20.86
Experimental	Mathematics	32	48.81	22.49
	Reading	37	49.84	20.57
	Writing	34	64.59	23.18

Figure 4.6  
Graphical Representation of the Main Effect of Time  
on Academic Functioning in Mathematics:  
All Subjects

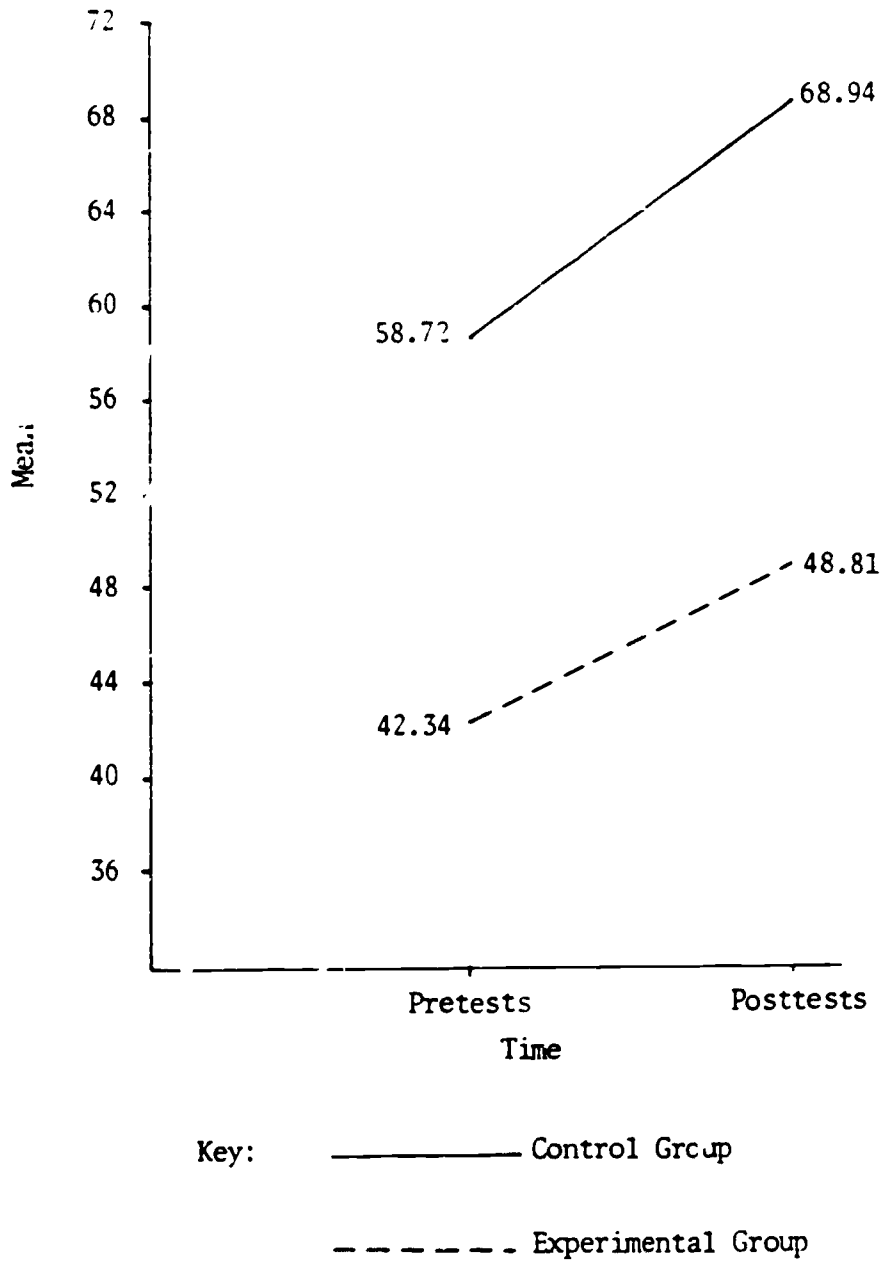


Table 18  
Multivariate Analysis of Variance with Repeated Measures  
of Academic Functioning in Mathematics: All Subjects

Source of Variation	SS	MSS	DF	F	P
<b>Main Effects</b>					
Group (G)	6066.090	6066.090	1, 44	6.30	0.016
Sex (S)	14.169	14.169	1, 44	0.01	0.904
Time (T)	1489.230	1489.230	1, 44	14.70	0.001
<b>Interaction</b>					
G × S	31.572	31.572	1, 44	0.03	0.857
G × T	127.143	127.143	1, 44	1.25	0.289
T × S	9.084	9.084	1, 44	0.09	0.766
G × S × T	130.974	130.974	1, 44	1.29	0.262
<b>Error</b>					
G × S	42343.316	962.348			
T × S × G	4457.902	101.316			

Key: Group = Control vs Experimental  
Sex = Male vs Female  
Time = Pretests vs Posttests

repeated measure was conducted, and the results are reported in Table 19. As was the case with mathematics, no interaction effects were found to be significant. Again the main effect for time was significant ( $p < .001$ ), and it can be observed that a greater mean gain (7.86) was obtained by the experimental group than by the control group (3.44) as can be seen in Figure 4.7.

#### 4.6.4 Writing

A multivariate analysis of variance with one repeated measure was also conducted to assess the presence of statistically significant differences between experimental and control groups in writing. As in the previous two instances, no interaction effects were found. However, main effects of time and group were significant ( $p < .05$ ). This indicated that (a) the two groups were significantly different at pretesting and (b) that subjects' performances changed significantly between pretesting and posttesting. Observation of the gains as represented in Figure 4.8 (13.76 for the experimental group compared to 2.34 for the control) suggest a substantial impact of the experimental intervention upon writing.

#### 4.6.5 Summary

From the foregoing it is concluded that there is insufficient evidence to support Hypothesis 3 with respect to mathematics, though there is sufficient evidence to support it with respect to reading and writing. It should be noted, however, that even in the case of mathematics there was gain during the experimental treatment.

### 4.7 Total Project--Hypothesis 4

**A significant difference would be found  
between the control and the experimental  
groups in respect to attendance.**

- 4.7.1 Descriptive statistics from the attendance scores for subjects in the control group and in the experimental groups are reported in Table 21. Results of an analysis of variance of these scores are reported in Table 22. Since the F-value was found to be statistically significant ( $p < .05$ ), it was concluded that sufficient statistical evidence existed to support this hypothesis.

Table 19  
Multivariate Analysis of Variance with Repeated Measures  
of Academic Functioning in Reading: All Subjects

Source of Variation	SS	MSS	DF	F	P
<b>Main Effects</b>					
Group (G)	2802.790	2802.790	1, 44	4.01	0.052
Sex (S)	444.344	444.344	1, 44	0.63	0.431
Time (T)	850.245	850.245	1, 44	12.64	0.001
<b>Interaction</b>					
G × S	688.422	688.422	1, 44	0.98	0.327
G × T	124.543	124.543	1, 44	1.85	0.181
T × S	98.753	98.753	1, 44	1.47	0.232
T × S × G	32.503	32.503	1, 44	0.48	0.491
<b>Error</b>					
G × S	30764.463	699.192			
T × S × G	5588.214	127.005			

Key: Group = Control vs Experimental  
Sex = Male vs Female  
Time = Pretests vs Posttests

Figure 4.7  
Graphical Representation of the Main Effect of Time  
on Academic Functioning in Reading:  
All Subjects

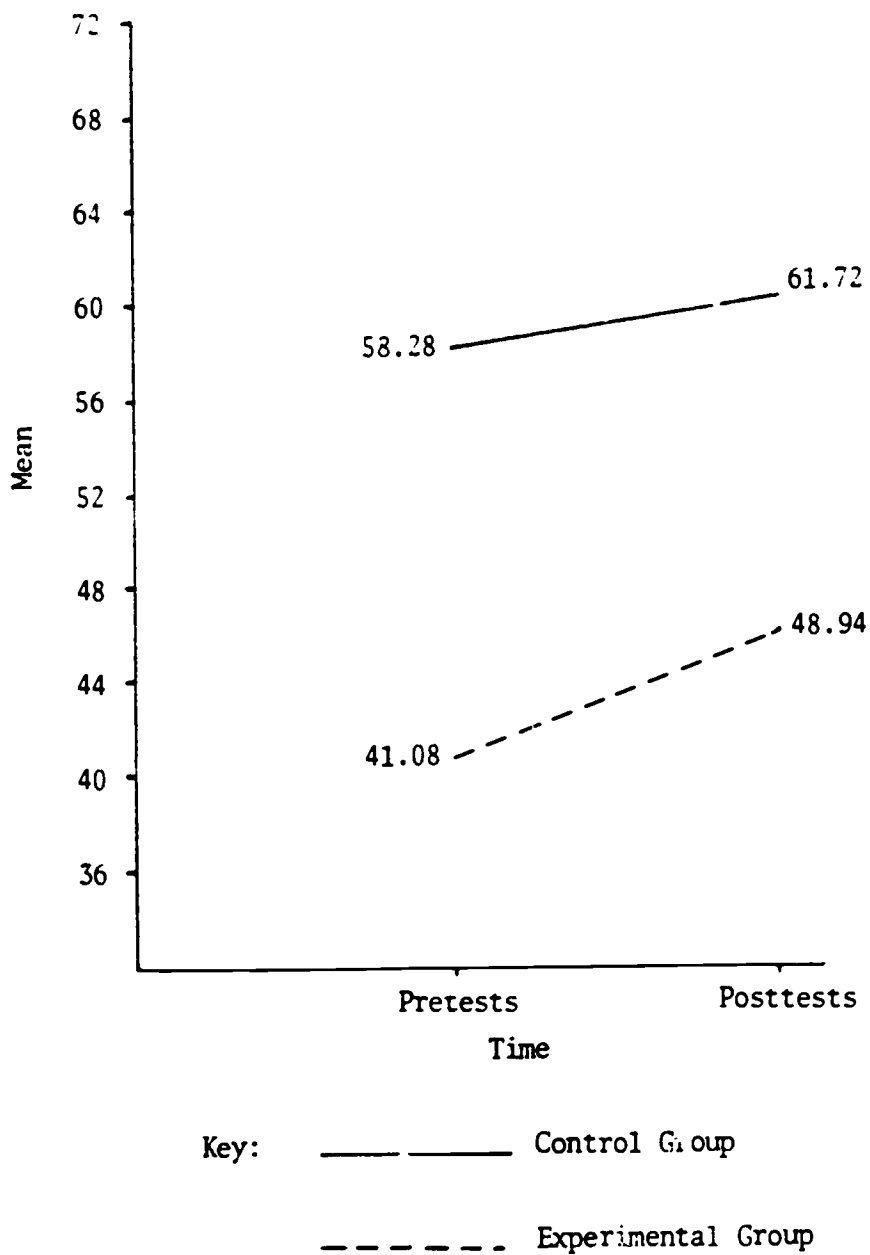


Figure 4.8  
Graphical Representation of the Main Effect of Time  
on Academic Functioning in Writing:  
All Subjects

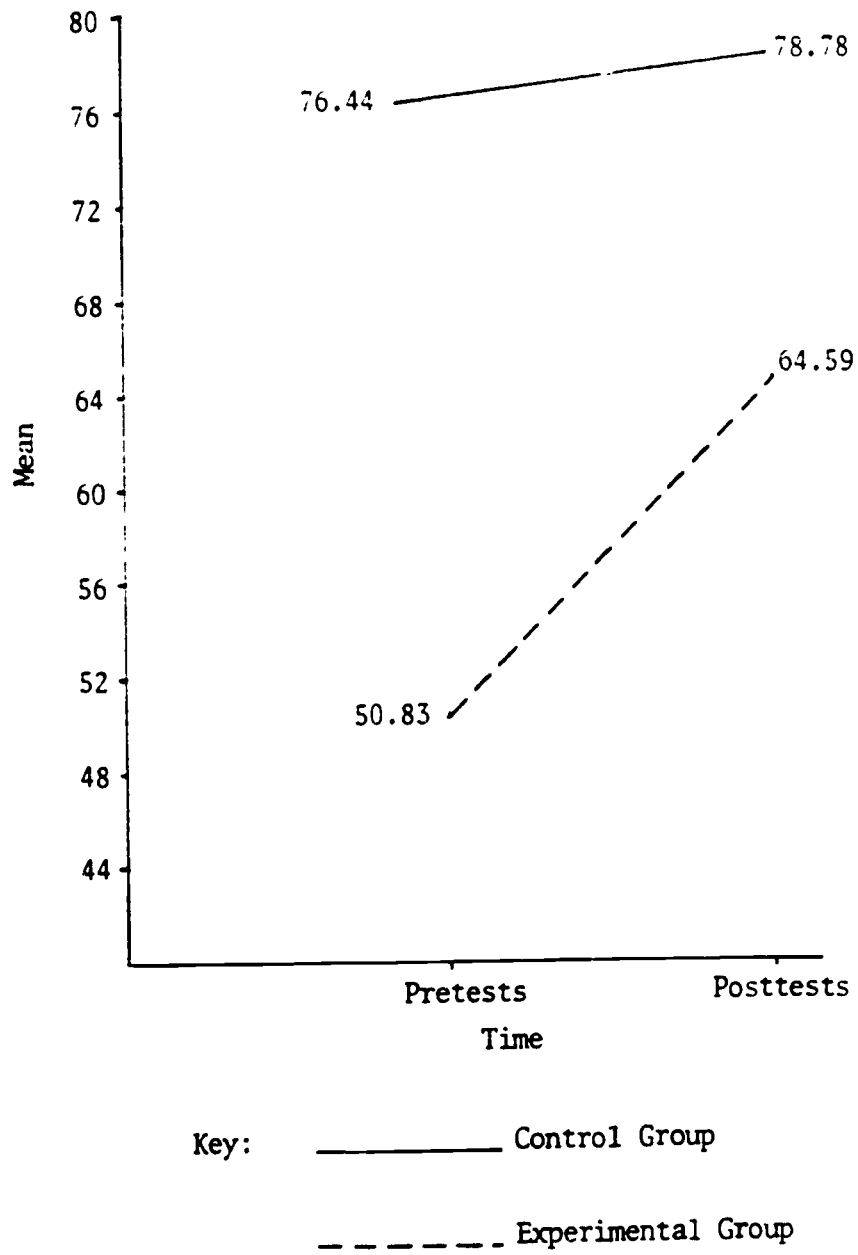


Table 20  
Multivariate Analysis of Variance with Repeated Measures  
of Academic Functioning in Writing: All Subjects

Source of Variation	SS	MSS	DF	F	P
Main Effects					
Group (G)	6531.700	6531.700	1, 44	6.54	0.014
Sex (S)	403.772	403.772	1, 44	0.40	0.528
Time (T)	1145.720	1145.720	1, 44	9.02	0.004
Interaction					
G × S	2912.520	2912.520	1, 44	2.92	0.095
G × T	460.343	460.343	1, 44	3.62	0.064
T × S	64.821	64.821	1, 44	0.51	0.479
T × S × G	18.850	18.850	1, 44	0.15	0.702
Error					
G × S	43915.575	998.081			
T × S × G	5588.214	127.005			

Key: Group = Control vs Experimental  
Sex = Male vs Female  
Time = Pretests vs Posttests

Table 21  
Descriptive Statistics  
for the Variable Attendance by Group:  
Control Versus Experimental

Group	Mean	Standard Deviation
Control	76.222	18.044
Experimental	89.842	9.669

Table 22  
Analysis of Variance of the Effect  
of Group on Attendance

Source of Variance	SS	MSS	DF	F	P
Between Groups	2265.765	2265.765	1	13.603	0.001
Within Group	8994.164	166.559	54		

### Summary of Analysis

1. Both experimental and control groups had had comparable experience with computers and with typewriters prior to this study;
2. On two tests assessing cognitive functioning, the performance gain of the experimental group, as assessed across time was superior to that of the control group.
3. On the third test assessing cognitive functioning (Representational Stencil Design Test) no significant difference was found between the control and experimental groups;
4. No significant difference was found to exist between subjects' attitudes towards mathematics as assessed by responses on pretest and on posttest;
5. A significant difference was found to exist between subjects' attitudes towards language arts as assessed by responses on pretests and on posttests;
6. With respect to level of academic functioning in mathematics a gain in mean difference score was observed, but this was less than the gain in the control group and it is not possible to make any assertions about the possible effect of the experimental intervention.
7. In respect to level of academic functioning in reading, the experimental subjects' performance changed significantly between pretesting and posttesting;
8. In respect to level of academic functioning in writing, a significant difference did exist between the two groups at pretest and all subjects' performance changed significantly between pretesting and posttesting--however a substantially larger gain was noted in the experimental group;
9. A significant difference in attendance was found to exist between the control group and the experimental group during the period in which the intervention program was being implemented.

## 5.0 DISCUSSIONS, OBSERVATIONS, AND RECOMMENDATIONS

### 5.1 Introduction

- 5.1.1 The problem involved in this study addressed the relationship between Native adolescents' academic underachievement and the underdevelopment of cognitive functioning believed to result from exposure to inadequate formal learning experiences. As an exploratory study, its primary purpose was to address the extent to which the improvement of cognitive functioning in such subjects may be facilitated. Hypothesis 1, which examined effects of a cognitive education intervention program on cognitive functioning, was the major hypothesis formulated to examine the overall problem. Hypotheses 2 and 4 addressed the effect of involvement in a cognitive education intervention program on subjects' attitudes towards mathematics, reading, and writing, and on their attendance in school. Hypothesis 3 examined the degree to which teaching for transfer of specific cognitive functions to mathematics, reading, and writing might affect students' achievements in these academic subjects.
- 5.1.2 In addition to these four hypotheses, the study also examined a number of other relevant issues. These additional concerns were (a) the degree to which teachers' attitudes towards their students might be affected by involvement in this cognitive education intervention program, (b) the generalization of behavioral changes in experimental subjects, and (c) the training of participating teachers. These concerns are addressed in this chapter through discussion of anecdotal findings and through observations made by this researcher. The chapter concludes with recommendations made for future research and development.

### 5.2 Hypothesis 1

- 5.2.1 The specific research question being considered through Hypothesis 1 was: To what extent can improved cognitive functioning be facilitated in academically underachieving Native adolescents? The results obtained from two of the three instruments used to test this hypothesis suggest that involvement in the intervention program did positively affect the experimental subjects' cognitive functioning abilities. A significant difference was found to exist between the control and experimental groups when the variances in their respective scores on the pretests and posttests of the LPAD, Variations I and II, were analyzed. As shown in Figures 4.1 and 4.2, the experimental group performed better on both assessment instruments at post-testing. Furthermore, the fact that these results were not significantly influenced by the variable of sex indicates that involvement in the intervention program similarly benefited both male and female subjects.

5.2.2 These results suggest that improved cognitive functioning can be facilitated in academically underachieving Native adolescents. In this respect, the findings from this study support the concept advanced by Feuerstein, Rand, Hoffman, and Miller (1980) that all humans have the capacity to change the structure of their cognitive functioning. This study extends their research by indicating that the concept of cognitive modifiability and change is also applicable to the Native adolescent.

5.2.3 These study findings also suggest that an intervention program can be successfully planned and presented in order to effect these changes in cognitive development. Consistent with the findings of Brown and her colleagues (Brown, 1975, 1979, 1982; Brown, Bransford Ferrar, Campione, 1983; Brown, Campione, & Day, 1981), the results indicate that the development of cognitive functions can be facilitated through the teaching of performance strategies.

5.2.4 In contrast to these results, however, analyses of performance on the Representational Stencil Design Test (RSDT), Parallel Form, presented some potentially different findings. While no significant difference was found between the control and experimental groups in their pretest scores, the analysis of variances in scores on pretests and on posttests indicated that both groups of subjects performed significantly better on the posttest. However, the finding that the difference in means of 8.98 realized by the experimental group (Tables 1 and 2) did not represent a significant improvement over the difference in means of 8.50 realized by the control group (Tables 1 and 2) suggested that the intervention program did not necessarily affect the performance of the experimental group.

5.2.5 One possible explanation of this particular result is that the instrument itself involved a learning process for both groups of subjects. During pretesting, both control and experimental subjects demonstrated a keen interest in the tasks on this instrument. It was observed that at the end of the testing session several subjects discussed with each other their responses to the tasks. Similarly, during the reporting back of both pretest and posttest results to subjects, several individuals indicated a higher level of interest in their performances on this test than on the other two. Thus, the instrument itself may have acted as an agent of change by encouraging further development of cognitive function already in the process of maturation.

5.2.6 An alternative explanation of this particular result is that the importance of the skill of sequencing to completion of tasks on this instrument may have been an important factor which was not sufficiently addressed in the intervention program provided to

experimental subjects. If this were true, the results obtained may have been caused by an adaptive effect taking place in both groups during the assessment process in that the Representational Stencil Design Test (RSDT) was the third test undertaken by both groups in pretesting and in posttesting. Had tests been randomly administered, this particular variable would have been controlled in the study. However, to properly identify the actual causes of these particular results, a further study would be needed to empirically determine the developmental process which did take place in both groups of subjects in respect to this test.

- 5.2.7 The results from the testing of Hypothesis 1 have a number of potentially important implications for educators concerned with assisting academically underachieving Native adolescents. The findings from all three instruments suggest that, where such adolescents demonstrate underdevelopment in cognitive functioning, this condition should not be considered a stable and sufficient predictor of future development. The analysis of the performances on Variations I and Variations II of the LPAD would appear to confirm the position, taken by the cognitive-modifiability theorists, that educators can assist such adolescents to alter the course of their cognitive development through the provision of mediated learning experiences.
- 5.2.8 The results obtained would also suggest that the procedures used in this exploratory study are potentially useful for educators concerned with underachieving Native adolescent students. As the findings from the initial assessment of underdeveloped cognitive function indicate, the combination of the psychometric assessment model, the dynamic assessment model, and the information-processing assessment model is a worthwhile approach to use in identifying cognitive functions requiring attention. It allowed for the economical assessment of this group of subjects and for the identification and interpretation of patterns of errors made by them. However, the process may still be limiting in its practical application since it requires special training and experience on the part of those undertaking interpretation of results. In order to make this assessment process more generally available to psychologists and to educators, more work is required to specify uniform criteria for making decisions about the relationships between patterns of errors on the assessment instruments and specific underdeveloped cognitive functions.
- 5.2.9 In respect to the design of a cognitive education program, findings from the testing of Hypothesis 1 would also suggest that the use of the LOGO programming is a potentially viable alternative to the pencil-and-paper instruments advocated by the structural modifiability theorists. Observations by the

researchers, together with anecdotal comments by participating teachers, strongly indicated that the opportunity to use computers proved to be a highly motivating factor in initiating and sustaining interest and involvement in the experimental program. Further, as postulated above the flexibility of the LOGO learning environment, and the element of control it afforded to the experimental subjects, did appear to encourage a sense of mastery and independence. In the anecdotal comments provided by the teachers, continual reference was made to changes observed in students' activities on the computer as the program progressed. One such statement by a teacher summarizes the changes noted by all four teachers:

The outstanding feature of this type of program lies in the self-confidence and ability to solve problems that the students attain after completing the course. At the beginning, the students lacked the confidence to try anything unfamiliar. If they did try a problem, and were unsuccessful, they would not try again. This all changed as they got familiar with the LOGO program, and it carried over into their math and language arts. The students will now experiment with different ways to solve a problem if the first attempt doesn't work.  
(Wells, personal communication)

- 5.2.10 Initially, prior familiarity with the use of computers was considered as presenting a potentially important influence on the performance of experimental subjects in the cognitive education program. It was felt that, if these subjects had had more extensive experience with the use of computers than did control subjects, this might have affected the performance of the former group. However, as the results obtained from the Computer Awareness Questionnaire indicate, no significant difference was found between control and experimental subjects in respect to prior experience with computers. This would suggest that prior familiarity was not a factor in subsequent findings concerning cognitive functioning.
- 5.2.11 The findings from the analyses of the responses on the Computer Awareness Questionnaire also had implications for some of the concerns raised by Micnayluk and Yackulic (1984) and discussed above. As noted above, all subjects involved in the present study had had prior experience with computers. While this experience primarily involved use of computers for playing games, the majority of subjects had also used computers for a variety of other purposes. This would suggest that, since they were already familiar with computers, use of this technology to create an environment for learning did not represent a new intrusion imposed on their culture. However because of the relatively small sample size involved in the present study, caution should be exercised in attempting to generalize findings to the population as a whole. Further research is still

required to determine if Native adolescents in general are sufficiently familiar with computers to ensure that use of this technology for learning purposes is culturally appropriate.

- 5.2.12 A final issue concerning the use of computers in the study involves the degree to which their effect on subjects' motivation influenced the results obtained. As Papert (1980) together with Krassnor and Mitterer (1984) have indicated, computers act as a highly motivating agent with underachieving students. This study supports this notion in that the experimental subjects were found to be extremely interested in learning about computers. While this variable undoubtedly had some influence on results, the degree of change in cognitive functioning found through the LPAD tests strongly suggests that the motivating influence of the computer could not have been the sole cause of the outcomes obtained. However, further research which would control for this variable is needed to determine its actual influence on subjects' performance.
- 5.2.13 In addition to implications for further use of LOGO in intervention studies of this nature, the findings from the testing of Hypothesis 1 suggest that attention to achieving improvement at the executive, or self-monitoring, level of cognition was beneficial for participating experimental subjects. The use of such training techniques as metacognitive development, modelling, decision-making, etc., was effective in achieving this improvement. This would appear to support the position stated in the rationale that development of cognitive functioning can be facilitated through the teaching of appropriate strategies. In other words, educators working with Native adolescents may reasonably consider a combination of cognitive training techniques from both the structural-modifiability and information-processing theorists as opposed to restricting considerations to either group of theorists.
- 5.2.14 The effectiveness of the approach taken in this study to facilitate cognitive development by utilizing actual school tasks suggests support for the position taken by the information-processing theorists in respect to this issue. In the context of underachieving Native adolescents, this finding suggests that teachers may not require unique, content-free programs in order to assist their students. Instead, students may be successfully taught to transfer, or to generalize, principles of effective cognitive processing through the use of school-related content. Examination of the effectiveness of this approach in influencing attitudes towards school subjects will be undertaken in the discussion of results obtained from testing Hypothesis 2.

5.2.15 As a further component of the overall process, the strategy of providing feedback to subjects concerning their performances on the tests proved to be an effective method of increasing metacognitive awareness in experimental subjects, and of encouraging continuing participation by control subjects. Subjects demonstrated a keen interest in this information. Many individuals voluntarily discussed situations in their personal lives where use of ineffective cognitive processing might have contributed to problems they had experienced. Several experimental subjects stated they were much more aware of the "steps" involved in problem-solving and in learning. In respect to control subjects, the final reporting back of cognitive test performances resulted in considerable discussion concerning ways in which they might improve their own cognitive processing abilities. Alternative strategies were discussed with each interested control subject and, where permission was obtained, recommendations were made to the appropriate school administrator.

5.2.16 In conclusion, the results from analyses of scores on all three instruments used to test Hypothesis 1 indicated that the concept of cognitive-modifiability is characteristic of underachieving Native adolescents. The findings from two of the instruments suggested that such modification can be achieved through a planned cognitive education intervention program. Additional research is necessary to determine the developmental process underlying performances on the third instrument. With the possible exception of development of sequencing skills, the findings demonstrated that the process and techniques used in this study were effective.

### 5.3 Hypotheses 2 and 4

5.3.1 The research question addressed through Hypothesis 2 was: Will students' attitudes towards specific academic subjects (mathematics and language arts) be affected by the teaching for transfer of cognitive functions to these academic subjects? Hypothesis 4 addressed the question of whether involvement in the cognitive education program by the experimental subjects would affect their school attendance relative to the control subjects.

5.3.2 The analyses of the results from the three scales, i.e., evaluative, usefulness, and difficulty, used to test Hypothesis 2 in respect to attitudes toward mathematics found no statistically significant evidence to suggest that teaching for transfer of cognitive functions affected the attitudes of the experimental group. In respect to the evaluative factor, the findings demonstrate that, relative to the control group, the degree to which the participants involved in the intervention program liked mathematics did increase in the period between assessments. Whereas the difference in means of the control

group declined by 0.28, the difference in means of the experimental group increased by 0.45 (Tables 6 and 7). Similarly, the degree to which the experimental group, relative to the control group, found mathematics to be useful also marginally increased by 1.48 points (Tables 6 and 7). In consideration of the degree to which subjects found mathematics to be difficult to learn, the trend in changed attitudes also favoured the experimental group by 2.67 points (Tables 6 and 7). Whereas the control group indicated that, in the period between pretesting and posttesting, they found learning of mathematics to be marginally more difficult, the experimental group found it to be somewhat easier. While these changes were not statistically significant, the consistency in the trends noted for the experimental group suggests that over a longer period of time the teaching for transfer of cognitive functions might have been significantly effective, especially in relationship to their responses on the difficulty scale.

5.3.3 In contrast to the results obtained concerning mathematics, the findings from all three scales assessing attitudes towards language arts provide clear indication that teaching for transfer was effective (Evaluation Scale:  $F = 8.30$ ;  $DF = 1, 42$ ;  $P = .006$ . Usefulness Scale:  $F = 7.71$ ;  $DF = 1, 42$ ;  $P = .008$ . Difficulty Scale:  $F = 5.58$ ;  $DF = 1, 42$ ;  $P = .023$ ). As reported in Tables 13 through 15 in, no statistically significant difference existed between the two groups at pretest. Similarly, no significant difference was found between males and females from these initial responses. A significant difference was found to exist, however, between the control and experimental subjects when the variances in their respective scores on pretests and on posttests were analyzed. These differences favoured the experimental group. Relative to the control group, the experimental participants indicated that, during the period between pretests and posttests, the degree to which they liked language arts and found that academic subject to be useful and easier to learn did increase significantly. The findings reported in Tables 13-15 also suggested that the variable of sex did not differentially affect these changes in attitudes. These findings would appear to suggest that underachieving Native adolescents' attitudes toward language arts can be positively affected by the teaching for transfer of cognitive functions to the learning of this academic subject.

5.3.4 In respect to Hypothesis 4, the results of the analysis of variance in attendance scores between the control and experimental groups, reported in Table 22, indicated that a significant difference was found to exist between these two groups of subjects. These differences clearly favoured the experimental group ( $F = 13.60$ ;  $DF = 1, 54$ ;  $F = 0.001$ ). Given the previous history of poor attendance by both groups, and the continuing low attendance of the control group, it would appear reasonable to conclude that involvement in the cognitive education program by experimental subjects did affect their improved attendance pattern.

- 5.3.5 Lack of perceived relevance of the formal learning program has been identified as a characteristic of many Native adolescents, and one which detrimentally affects their attitudes toward academic subjects (Hawthorn, 1967). However, the findings from both assessments of attitudes in this study suggests that this particular sample possessed a generally neutral attitude toward mathematics and language arts. This would suggest that Hawthorn's (1967) argument that Native adolescents consider the learning of these academic subjects to be irrelevant may not be applicable today. Further research, however, would be required to resolve this question.
- 5.3.6 The finding that teaching for transfer of cognitive functions to language arts did significantly improve subjects' attitude towards that academic subject has important implications for educators. A number of reviewers have documented the problems many Native adolescents experience in language learning in school (e.g., Burnaby, 1980, 1982; Cummins, 1979; Ohannessian, 1972). As a result, it would seem that utilization of the approach taken in this study should be carefully considered as a means for alleviating this problem. Among other positive attitudinal changes noted, experimental subjects clearly indicated that they found it easier to learn language arts as a result of being taught to transfer effective cognitive functions to that academic subject. Similarly, the results from the scales assessing attitudes towards mathematics would suggest that experience in this process was also positively affecting ability to learn that subject. These findings would also seem to support the position taken by Brown, Bransford, Ferrara, and Campione (1983) that academic subjects can successfully be included in a cognitive education intervention program.
- 5.3.7 The phenomenon of poor school attendance by underachieving Native adolescents is well established. As a result, the finding that involvement in the cognitive education program significantly affected attendance is of obvious importance to educators. In addition, this finding is supported by the reports from the cognitive education project with Navajo Native adolescents at Shiprock Alternative High School, referred to above.
- 5.3. It may be concluded, then, that teaching for transfer of cognitive functions to mathematics can affect some attitudinal changes. Even clearer indication of the effectiveness of this approach was found from the analyses of responses when assessing attitudes towards language arts. The results from both sets of analyses did not support the belief that underachieving Native adolescents characteristically perceive learning of these academic subjects to be irrelevant. Finally, involvement in the cognitive intervention program was shown to positively affect student attendance in school.

5.4

Hypothesis 3

5.4.1 The research question specifically addressed in Hypothesis 3 was: Will the teaching for transfer of specific cognitive functions to certain academic subjects improve students' achievements in these subjects? The academic subjects selected for consideration in this study were mathematics, reading, and writing.

5.4.2 Mathematics

5.4.2.1 The results from the analyses of scores on the instrument used to assess academic functioning in mathematics found no statistical evidence to suggest that the teaching of specific cognitive functions improved experimental subjects' achievement in mathematics.

5.4.2.2 As the results reported in Table 18 indicate, the two groups of subjects did differ in their performances on the assessment instrument at pretesting ( $F = 6.30$ ;  $DF = 1, 44$ ;  $P = 0.016$ ). This finding was not unexpected in that the respective schools had not considered it necessary to place these students in special classes. Figure 4.6 shows that, at posttesting, the control group also realized a greater gain in scores on the instrument.

5.4.2.3 In contrast to the conclusion reached from the statistical analysis, anecdotal comments by teachers, although lesser in reliability, did suggest that they had observed positive changes in individual students in respect to mathematics learning as a result of teaching for transfer of cognitive functions. According to the participating teachers, evidence for this conclusion was found in improvements on the ongoing assessments of the experimental subjects. These separate assessments were carried out by the teachers as a regular component of the teaching process. In particular, the teachers reported that their assessments indicated major change in students' understanding of the process of problem-solving in mathematics. This observation would also seem to be supported by the indication from responses on the attitude scales that experimental subjects seemed to find that mathematics was becoming easier to learn.

5.4.2.4 An explanation of the discrepancy between the statistical results and the anecdotal comments of the teachers may, perhaps, be found in Anastasi's remark that "It takes a long time, however, to accumulate the relevant content store in long-term memory . . . it is . . . unrealistic to expect this to occur after short raining periods distributed over a few months" (Anastasi, 1981, pp. 1090-1091). The Canadian tests of Basic Skills, as an achievement battery, presupposes that the student

would have had opportunity to accumulate such a content store. In respect to the experimental subjects, Anastasi's position would suggest that the training program was of insufficient duration for those students to accumulate the necessary content. It would, therefore, appear that the length of time necessary to determine whether improvement could be effected by this method in the experimental group was underestimated in the research design. Since the only indication that the teaching for transfer of specific cognitive functions to mathematics did improve student achievement is anecdotal comment, recommendations for general application of this approach cannot be made with any degree of confidence. Further research is necessary to adequately resolve this question.

#### 5.4.3 Reading

5.4.3.1 The results from the analyses of performances on the instrument used to assess academic functioning in reading provide statistical evidence to suggest that the improvement of cognitive functioning positively affected experimental subjects' achievements in that academic subject. As Table 19 indicates, the difference between control and experimental subjects at time of pretesting was approaching significance ( $F = 4.01$ ;  $DF = 1, 44$ ;  $P = 0.052$ ). Figure 4.7 shows that difference clearly favoured the control subjects. As with mathematics, this finding was to be expected since the control subjects were considered by their respective institutions to be sufficiently capable in reading ability to function in a regular classroom situation. Table 19 also demonstrates that a significant difference in scores on the assessment instrument was found between pretesting and posttesting. As may be seen in Figure 4.7, the experimental subjects accounted for the greater proportion of this change.

5.4.3.2 Anecdotal comments by teachers also support the statistical evidence of this improved reading ability in experimental subjects. The teachers report that, as students became more aware of the purpose of reading, and of its importance to their academic and personal lives, they demonstrated greater interest in the reading process. In particular, teachers found that, as the program progressed, students demonstrated increasing interest in learning the strategies necessary for effective reading. It was found that stressing the relationship between students' own prior knowledge and the new knowledge available from texts facilitated the students' comprehension of that new knowledge.

5.4.3.3 The combination of assessment results and anecdotal comments made by teachers lead to the conclusion that the teaching for transfer of specific cognitive functions did improve these students' achievements in reading. Given the findings from

other research, referred to earlier, concerning the difficulties experienced by many Native students in language arts programs, this finding has important implications for educators. While generalizations are difficult to make because of the relatively small size of this particular sample, nevertheless the findings do indicate that further exploration of the potential of this approach for assisting academically underachieving Native adolescents is justifiable.

#### 5.4.4 Writing

5.4.4.1 The results from the analyses of scores on the instrument used to assess academic functioning in writing also found sufficient statistical evidence to suggest that teaching of specific cognitive functions did improve experimental subjects' performances. As the results reported in Table 20 demonstrate, the two groups of subjects did differ significantly at time of pretesting ( $F = 6.54$ ;  $DF = 1, 44$ ;  $P = 0.014$ ). Table 20, however, also indicates that a significant change did take place in the period between pretesting and posttesting ( $F = 9.02$ ;  $DF = 1, 44$ ;  $P = 0.004$ ). As may be seen in Figures 4.18 and 4.19, this difference was primarily influenced by scores obtained by the experimental group.

5.4.4.2 The statistical evidence of the effectiveness of this approach in improving writing ability is strongly supported by the anecdotal comments of teachers. In particular, teachers observed that use of the Bank Street Writer word processing package was especially effective. Students were found to be more willing to write several drafts of their texts on the computer. Teachers reported that, previously, they had experienced considerable difficulty in encouraging students to undertake such redrafting when a pencil-and-paper approach was required.

5.4.4.3 Teachers also reported that the technique of conferencing was effective in that it provided an efficient method of providing individual attention to students. As they gained more experience with the process, students were found to become more objective in their criticisms of their own writing. The students became more capable of identifying components which were inadequately developed or elaborated. The teachers also found that, as students gained more competence in constructing text, they also became more conscious of the need to be attentive to the conventions of writing, i.e., punctuation, capitalization, sentence structure, etc. In this respect, this study supports the position taken by Temple and Gillet (1984) that conferencing is an effective training method for improving writing abilities.

- 5.4.4.4 The technique of encouraging students to select their own topics to write about also proved to be an effective approach. Teachers reported that, at the beginning, several students experienced some difficulty in choosing a topic. However, as the program progressed, this became less of a problem and many students were found to become enthusiastic about being able to write on topics of particular interest to them.
- 5.4.4.5 Based on these assessment results and supportive anecdotal comments by teachers, this research concludes that, with this sample, the teaching for transfer of cognitive functions to writing did improve performances in that academic subject. In the context of academically underachieving Native adolescent students, this finding is of importance to educators. The improvement of writing ability is well established as being of major concern for such students. Given the potential effectiveness from general application of this approach, as demonstrated in the findings from this study, its use in further experimental studies is justifiable.
- 5.4.4.6 In conclusion the discrepancy between the results obtained from the statistical analyses of scores on the instrument used to test the effectiveness of teaching for transfer of cognitive functions to mathematics and the observations of teachers suggest that further investigation is required to resolve this issue. It would appear that, while positive changes in performances were observed, a longer period of training may be necessary for subjects to accumulate a sufficient content store in long-term memory before such improvements may become empirically significant. In contrast, the analyses of scores on the instruments assessing reading and writing abilities found sufficient evidence to indicate that teaching for transfer of cognitive functions to those academic subjects was effective. These findings were also supported by teacher observations. In addition, teachers indicated that the teaching techniques suggested in the Teachers' Manuals provided to them were appropriate and effective. The overall findings from the testing of Hypothesis 3 suggest that further experimental studies investigating the potential for general use of this approach with academically underachieving Native adolescents are justified.

## 5.5

### Research Question 4

- 5.5.1 The fourth research question being considered in this study was: Will involvement in this cognitive education intervention program affect teachers' attitudes toward their Native adolescent students? No specific hypothesis was formulated to address this research question. Instead, anecdotal reports concerning this question were requested from the participating teachers. In general, the comments made by teachers focussed on three areas of change they identified in their attitudes towards their students as a result of involvement in this study: their

perceptions of the students' learning abilities, their understanding of the extent of the students' prior knowledge base, and their changed pattern of reaction to students' behavior.

5.5.2 In respect to perceptions of the students' learning abilities, there was consensus of opinion that involvement in this program had resulted in change of attitude on the part of all four teachers. The information on each student made available from the initial assessments provided a depth of understanding of individual student's strengths and weaknesses not previously realized by the teachers. In addition, the identification of specific underdeveloped cognitive functions in students provided the teachers with a greater understanding of possible causes of learning difficulties being experienced by their students. The information provided from the investigation of these initial assessments also indicated areas of strength in cognitive processing abilities that had not previously been identified. Consequently, the teachers found that their expectations of academic functioning by students were, in the past, generally inappropriate for the students' actual abilities. As the program progressed, teachers became more aware of the potential abilities of their students and, as a result, more consistent and realistic in terms of appropriate standards of performance demanded of students.

5.5.3 In addition to the influence of the intervention program on teachers' expectations of students, the anecdotal comments of teachers also addressed changes in their understanding of the extent of students' own knowledge base. Since the process of teaching, required by the program, involved identification of this prior knowledge, and its relationship to the new knowledge being presented, the teachers were made more aware of this factor. In general, the teachers indicated that they discovered students knew a great deal more about a variety of topics than had previously been assumed. On the other hand, the teachers also discovered major gaps in knowledge which were influencing students' learning achievements. One example of such lack of knowledge, assumed to exist, was identified by the Native teacher involved in the research project. This referred to specific cultural knowledge and historical information of Cree Indian people. As a result, the teacher became more understanding of students' restricted abilities to participate in cultural and community activities and in relationships with community elders. Overall, increased understanding of the strengths and weaknesses of their students in respect to the extent of relevant knowledge accumulation resulted in a deeper appreciation of students' needs.

- 5.5.4 In regard to the third area of attitudinal change, the teachers indicated that, as the program progressed, they began to react in a more positive and supportive manner to their students. Whereas they had previously often become emotionally upset over particular behavioral responses of students, the teachers found that, as students demonstrated more reflective rational thinking, more independence, and more orientation toward acceptance of responsibilities, they too were more objective in their reactions. Their particular comments in respect to this may be summarized in the words of one teacher: "Emotional reaction on my part is rarely necessary any more because other methods seem to work much better" (Ramey, personal communication). In summarizing his opinion of the positive effect on him of involvement in the cognitive education program, one teacher stated that "This program was very rewarding to me as a teacher and I hope to make use of it again next year in my teaching" (Wells, personal communication).
- 5.5.5 Although consistent with the findings of the structural-modifiability theorists, these anecdotal reports do not provide sound empirical evidence that involvement in a cognitive education program of this nature will positively affect teachers' attitudes towards academically underachieving Native students. However, they do indicate that further consideration of such an approach to improving teachers' attitudes towards this population is justifiable. If such further research could provide empirical evidence that teachers' attitudes are positively affected by involvement in a cognitive education intervention approach to assisting such students, the finding would have major implications for Native education in general.
- 5.6 Other Findings From The Study
- 5.6.1 Although not specified as research questions in this study, other findings were identified which are of potential importance for future research involving academically underachieving Native adolescents. This section briefly addresses these additional findings.
- 5.6.2 Generalization of Behavioral Changes in Experimental Subjects
- 5.6.2.1 As indicated previously, experimental subjects involved in this study had had a history of behavioral problems in school and in their personal lives. While no research questions were developed concerning this, comments were made by teachers, by school administrators, and by some parents in respect to their observations of generalization of changed behavioral patterns by these students as a result of involvement in this cognitive education intervention program.

- 5.5.2.2 The participating teachers reported that the students' general behavioral patterns had improved remarkably during the period the program was in effect. At the beginning of the program these teachers had observed that such friction existed between the students in each of the four experimental study groups. This friction often resulted in fighting and in other forms of physical abuse. As the program progressed, however, behavioral change was noticeable in that this friction became much less pronounced, and students cooperated more readily with each other. As these interactional patterns of behavior changed, the teachers reported that students' attitude towards their own classrooms generally improved. In one study group, this resulted in subjects deciding to scrub off graffiti, etc., from the walls and to decorate the room more appropriately.
- 5.6.2.3 School administrators commented that they observed a considerable improvement in the experimental subjects' general behavior in school. Prior to the program, these students had had a generally belligerent attitude towards other students, staff, and administration. However, this attitude was observed to change as the students became involved in the intervention program. The administrators also reported that the attitudes of other staff members towards these students improved to the point where, in one study group, staff members voluntarily invited the subjects to go on golfing and canoe trips.
- 5.6.2.5 At a parent involvement evening for one group of experimental students, some parents volunteered their opinion that the behavioral changes occurring in school were generalizing to behavioral patterns at home. One parent commented that his son had become "more human" again since the intervention program had started. Other parents stated their children were becoming "more relaxed" and less antagonistic towards them and towards siblings. Additionally, some parents noted that their children had begun to discuss what they were learning in the program whereas, prior to this program, these children never voluntarily discussed school or learning activities.
- 5.6.2.6 Findings such as these appear to be consistent with those of cognitive-behavioral modification researchers. Alternatively, however, these behavioral and attitudinal changes may have occurred simply as a result of normal development or of the increased attention being given to the subjects by their teachers. The actual extent of generalization of behavior and attitudinal changes, and the relationship between them and the variables addressed in this study, cannot be determined without further research. Given the indications of such possible generalizations, however, this further research would appear to be warranted.

### 5.6.3 Training of Participating Teachers

- 5.6.3.1 If the approach to teacher preparation used in this study can be demonstrated as an effective means of improving teachers' attitudes towards students, it would represent a more economically feasible and efficient method than that advocated by the structural-modifiability theorists. Feuerstein and his colleagues (Feuerstein, Rand, Hoffman, & Miller, 1980) have suggested that an extensive and intensive system of training is required in order to prepare teachers adequately to implement a cognitive education program.
- 5.6.3.2 The findings from this study suggest that such an alternative approach to training of participating teachers may be considered. In general, the teachers were satisfied with the extent of training and support provided. However, they did indicate that further training in utilizing bridging as a teaching technique would be helpful. In particular, the non-Native teachers commented that their limited knowledge of the students' cultural backgrounds and community restricted these teachers' ability to bridge successfully and consistently from classroom learning activities to appropriate experiences in the students' personal lives. Further in-service training would seem to be necessary to fully develop non-Native teachers' competency in this component of the program. All four teachers also indicated that training in analyzing patterns of errors in student performances would be beneficial. A final recommendation made by the teachers concerned the need for training in strategies for cognitive-behavioral modification in order to deal more effectively with some students.
- 5.6.3.3 In summary, it would appear that, with additional attention to training in methods of bridging, in analyzing patterns of errors in student performances, and in strategies for cognitive-behavioral modification, the approach taken to preparing teachers for this type of program involving academically underachieving Native adolescents was effective. However, given the very small number of teachers sampled, extreme caution has to be exercised in attempting to generalize this finding to other teachers. In addition, consideration should be given to the possibility that the degree of attention given to these teachers by the research team influenced their motivation to perform effectively. Further research is obviously required to resolve this question.

### 5.7 Limitations

- 5.7.1 The findings indicate some limitations to the study which should be noted. For one thing, the duration of the program may have been inadequate to fully investigate the potential effect of teaching for transfer of cognitive functions to mathematics.

- 5.7.2 A further major limitation of the study concerns the need to assess long-term effects of training. In this respect, Feuerstein (Feuerstein, Rand, Hoffman, & Miller, 1980) has stated that the more remarkable gains in cognitive functioning abilities appear to occur three to five years after termination of a cognitive education program. Sternberg (1981a) has criticized the general lack of longitudinal research in cognitive education. Without knowledge of long-term effects, he suggests that investigators may pursue training methods of which the short-term benefits are not matched by even the smallest long-term gains.
- 5.7.3 Without information of long-term effects, overall conclusions of the effectiveness of cognitive education for ameliorating learning problems of academically underachieving Native adolescents must be considered as being tentative. However, given the findings of this first study of this nature with this population, further research requiring investigation of long-term effects would appear to be defensible. Prior to being able to indicate potential effectiveness of this approach in assisting their children, it was not possible to convince the parents to give permission for a longitudinal study.
- 5.7.4 An additional limitation of this study is its lack of controlling for the possible effect of motivation on outcomes. As Roethlisberger and Dickson (1939) demonstrated, when subjects are aware that they are members of an experimental group, performance may improve simply by virtue of that fact. Without controlling for this Hawthorn effect, it is impossible to adequately determine its actual influence on results.

## 5.8 Recommendations For Further Research

- 5.8.1 The implications of the present study are limited by the restricted samples which were selected, by the need for longitudinal research, and by the lack of control for the effect of motivational variables. Suggestions for further study of the potential of cognitive education for ameliorating learning problems of underachieving Native adolescents are related to .. basic shortcomings.
- 5.8.2 There is a need to replicate this study with other under-achieving Native adolescents in order to properly determine its actual potential for assisting such adolescents in general. In this respect, this further research should also include comparative studies investigating differential effects of cognitive education, of supplementary education, and of remedial education. Controlled, empirical research of this nature is needed in order to investigate the relative effectiveness of cognitive education approach, as opposed to others, to alleviating problems experienced by academically underachieving Native adolescents.

- 5.8.3 The lack of control for the Hawthorn effect in the present study leaves unanswered the question of its influence on the results obtained. In future research, motivational interventions should be conducted conjointly with cognitive interventions in order to adequately investigate this issue.
- 5.8.4 The lack of longitudinal research in the present study prevents any conclusions being made concerning the long-term effect of cognitive education on academically underachieving Native adolescents. Further research investigating the actual potential usefulness of this approach must include assessment of long-term effects.
- 5.8.5 A direction for future research concerns reconciliation of the question of how academically underachieving Native adolescents view the relevancy of academic subjects as these are presented in school. The findings in the present research appear to contradict the position taken by Hawthorn (1967) on this issue. However, the relatively small size of the present sample suggests caution in generalization of findings to Native adolescents in toto. However, since Hawthorn suggested that lack of perceived relevance of academic learning was a major factor influencing Native adolescents' performance in school, reconciliation of the issue is important.

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## A p p e n d i x   A

Name: \_\_\_\_\_

(1) Code: \_\_\_\_\_

(2) Age: \_\_\_\_\_

(3) Grade: \_\_\_\_\_

(4) Sex: M F

**Familiarity with Computers**

(5) Have you ever used a computer before? NO YES

IF YES, how have you used them and how often?

		0	1	2	3	4	
(6)	Playing computer games	NO	YES	Once a Year	Once a Month	Once a Week	Almost Daily
(7)	Writing computer programs	NO	YES	Once a Year	Once a Month	Once a Week	Almost Daily
(8)	Writing essays, letters, etc.	NO	YES	Once a Year	Once a Month	Once a Week	Almost Daily
(9)	Being taught by computer	NO	YES	Once a Year	Once a Month	Once a Week	Almost Daily
(10)	Looking for books in a library	NO	YES	Once a Year	Once a Month	Once a Week	Almost Daily
(11)	Other: _____	NO	YES	Once a Year	Once a Month	Once a Week	Almost Daily

**Familiarity with Typewriters**

(12) Have you used a typewriter? NO YES Once a Year Once a Month Once a Week Almost Daily

A p p e n d i x   B

January 7, 1985

During this term our school will be offering a 5-month program for a number of students involving approximately one hour a day. Your son/daughter is one of the students chosen for this program.

We wish to identify particular problems which students may be having with school learning and provide them with some help in overcoming these difficulties. At the same time we would like to help the students to develop a positive attitude toward learning the various school subjects.

This program will be part of the regular school program. The first part will be designed to help the students to further develop thinking skills which are needed for effective learning in junior high school. The second part will help the students apply these skills to the learning of mathematics and English.

To carry out this program we need to administer a small set of paper and pencil tests to each student. Some of the tests will help us to identify problems the students may be having with thinking skills. We will also need to find out their level of ability in mathematics and language at the start of the program. Another test will help us to identify the students' attitude towards learning school subjects. We will ask students to take similar tests part-way through the program and again at the end of the program to see how effective it has been.

We will be careful about making sure confidential information about your son or daughter is protected. Because of this we will identify each student by a number only. At no time will students' names be used in any report about the program. At the end of the program all information traceable to individual students will be destroyed.

Because we feel it is important that parents be provided with as much information as possible about their children, we will be pleased to discuss the project with you at any time. The people from the University of Calgary who are helping with the project have agreed to make themselves available at the end of the project to give you as much information as they can about your son or daughter. They may be able to make suggestions of further help to your child.

---

I grant my permission for \_\_\_\_\_ to participate in the program and be given the tests described above.

Signed: \_\_\_\_\_

January 7, 1985

During this term a pilot program for Native junior high school students is taking place in some of the schools in our district. This program is designed to help students further develop thinking skills which are needed for effective learning in junior high school and to apply these skills to the learning of mathematics and English.

To carry out this program a small number of paper and pencil tests are being administered to the participating students. Some of the tests will help identify problems students may be having with thinking skills. Two others will help identify their level of ability in mathematics and language. Another will help identify the students' attitudes towards learning school subjects. The students will be asked to take similar tests part-way through the program and again at its end in order to test the effectiveness of the program.

This program is not being conducted in our school this term. However, in order to evaluate the effectiveness of the pilot program it is necessary to administer the tests to students who are not taking part. Our school has volunteered to participate in this way and to administer these tests to students for whom their parents/guardians grant permission. (No student will be forced to participate against his will.)

We will be careful about making sure confidential information about your son or daughter is protected. Because of this we will identify each student by a number only. At no time will students' names be used in any report about the program. At the end of the program all information traceable to individual students will be destroyed.

Because we feel it is important that parents be provided with as much information as possible about their children, we will be pleased to discuss the project with you at any time. The people from the University of Calgary who are helping with the project have agreed to make themselves available at the end of the project to give you as much information as they can about your son or daughter. They may be able to make suggestions of further help to your child.

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I grant my permission for \_\_\_\_\_ to be given the tests described above.

Signed: \_\_\_\_\_

A p p e n d i x C

COGNITIVE EDUCATION INTERVENTION PROGRAM

Table of Contents

Introductory LOGO Computer Language Component

Lesson

- 1 Introduction to the computer. Disk maintenance.  
Turning on the computer.
- 2 Review. Keyboard. "Apple presents Apple".  
LOGO: Loading and copying.
- 3 Review keyboard. Print. Draw. LOGO Primitives.
- 4 Review Primitives. More Primitives. Turtling around.
- 5 Screen control. Exploring. Initializing a disk.  
SAVEPICT. READPICT.
- 6 REPEAT. Editor: Writing procedures.
- 7 Revise Editor. Pattern Building. SAVE. READ.
- 8 Circles. List commands. Erase commands.
- 9 Review. Free drawing.
- 10 More exploring: Little steps and tiny angles.
- 11 Circles and arcs. Review SAVE, READ and related  
commands.
- 12 & 13 More procedures. Review screen control commands.
- 14 Variables.
- 15 Variables. MAKE. Calculation.
- 16 Review. Free drawing.
- 17 Recursion.
- 18 Recursion with variables.
- 19 STOP. Growing procedures.
- 20 POLY.

- 21 Design planning and breakdown.
- 22 Defining repeated elements. Linking repeated elements.
- 23 Defining unique parts.
- 24 Linking parts. Subprocedures with variables. Growing.
- 25 Writing procedures for whole design.

Extended LOGO Computer Language Component

- A Introduce Word Processing.
- B Further Exercises:

Exercises

- 1 Draw a square with a side of 60.
- 2 Adding, Subtracting, Multiplying, Dividing.
- 3 Extending Exercise 1.
- 4 Leaving the math to the computer.
- 5 Write a procedure called FOURSQ.
- 6 Review of variables.
- 7 Procedure for any regular polygon.
- 8 Rotating polygons.
- 9 Challenge.
- 10 Conditional Statements.
- 11 More about conditionals.
- 12 Recursion.
- 13 Recursion again.
- 14 Recursion one more time.
- 15 Interactive programs.
- 16 Interactive programs using numbers.
- 17 Interactive drill and practice program.

Mathematics

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Subtraction Facts: 1

Addition Patterns

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Computations Involving Fractions

Problems Involving Fractions

Fractions and Cognitive Functioning

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Decimals for Length

Adding and Subtracting length

Decimals for Squares

Numbers in Order

Reading Scales

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To Find a Percentage of a Number

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Interest

Follow-up Activities

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Content Selection

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Recognizing Signals Used by Authors

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Sequence

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Comparison and Contrast

Note to Teacher

Sample Lesson

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Definition

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Modifiers

Restatement

Inference

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Repetition of Key Words

Familiar Connectives

Sample Lessons

Writing

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How to Introduce the Reading Component

Activity 1 : Getting Started

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Note to Teacher

3 Step Two

Note to Teacher

4 Step Three

Note to Teacher

5 Step Four

Note to Teacher

Activity	6	Conventions
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		Capitalization
		Spelling
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	9	Additional Notes
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		Content